GRAPHICAL USER INTERFACE AND JOB DISTRIBUTION OPTIMIZER FOR A VIRTUAL PIPELINE SIMULATION TESTBED

By

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CHAPTER 1: PROJECT OVERVIEW

1. Purpose

The purpose of this project is to develop a virtual pipeline simulation testbed. The simulation will model the pressure and flow rate distribution of gas in a real pipeline system.

2. Goals

The design and implementation goals are:

- Design a GUI to create and manipulate the pipeline system.
- Implement an optimizer to efficiently distribute computation among several machines.
- Integrate the GUI with a simulator that will simulate the behavior of each component of the real pipeline system by solving a set of particular partial differential equations.

3. Constraints

When developing a simulation, the main constraint is the time. The simulation has to run in a reasonable amount of time. For this reason, the software will use various parallel and distributed algorithms. Another constraint is the space constraint (memory). The project will take into consideration those constraints and will be designed to optimize the use of time and space.

CHAPTER 2: Software Requirement Specification

1. Introduction

1.1Purpose

The purpose of this Software Requirement Specification is to establish and maintain a common understanding between the customer, Dr. Wallentine, and the software developer regarding the requirements for the proposed software.

1.2 Scope

The proposed software is a GUI and a job distribution optimizer for a virtual pipeline simulation testbed. The software will simulate the pressure and flow distribution that is happening in a real pipeline system. The software will use various parallel algorithms on several machines in order to reduce the amount of time needed by this computing-extensive simulation. The software will also provide a GUI to graphically build the pipeline system and will perform the require computation in order to have a simulation as accurate as possible in a reasonable amount of time. The GUI will also be used to visualize the result of the simulation.

1.3 Overview

This Software Requirements Specification (SRS) is organized into two main sections: overall description and specific requirements. The overall description section provides information describing general factors that will affect the requirements of the software. The specific requirements section describes in detail the requirements the software must meet.

2. Overall description

2.1 Product perspective

The software is an interface to the Virtual Pipeline Simulation Testbed. It comprises a GUI (Pipeline Editor) and a job distribution optimizer (Optimizer). Once the pipeline system is drawn, the optimization and the simulation will be able start. The computation will be done on several powerful computers and result will be transmitted back to the

GUI for display. Communication among cluster machines will be done by message passing and shared memory.

2.2 User interface: Pipeline Editor

a) The pipeline editor shall support drag and drop operations for drawing components (pipes, joints, and compressors).
b) The pipeline editor shall support standard editing functions (copy, cut, paste).
c) The pipeline editor shall provide zoom functions.
d) The pipeline editor shall display the simulation results.
e) The user shall be able to store/retrieve a previously drawn pipeline system (group of components called library) and connect it with some new groups or components.
f) The user shall be able to move components inside the editor to have a better positioning.
g) The user shall be able to edit the characteristic of each component displayed.
h) The user shall be able to define some checkpoints during the simulation.
i) The user shall be able to playback (replay) the simulation from any given checkpoints.
j) The user shall be able to start the application from any machines (using a browser and WebStart).
k) At any time during the simulation, the user shall be able to interrupt the simulation.

2.3 Hardware interfaces

a) Each computer shall have enough memory and enough computing power (processors) to handle computing-extensive tasks.
b) Each computer shall have an Ethernet card to communicate with other computers.

2.4 Software interfaces

a) The cluster computers shall run under the Linux operating system.
b) Each computer shall have the Java Virtual Machine installed (version 1.4 or later).
c) Each computer shall have the JGraph 3.0 package installed.

2.5 Communications interfaces

Computers shall support TCP/IP to communicate with each other.

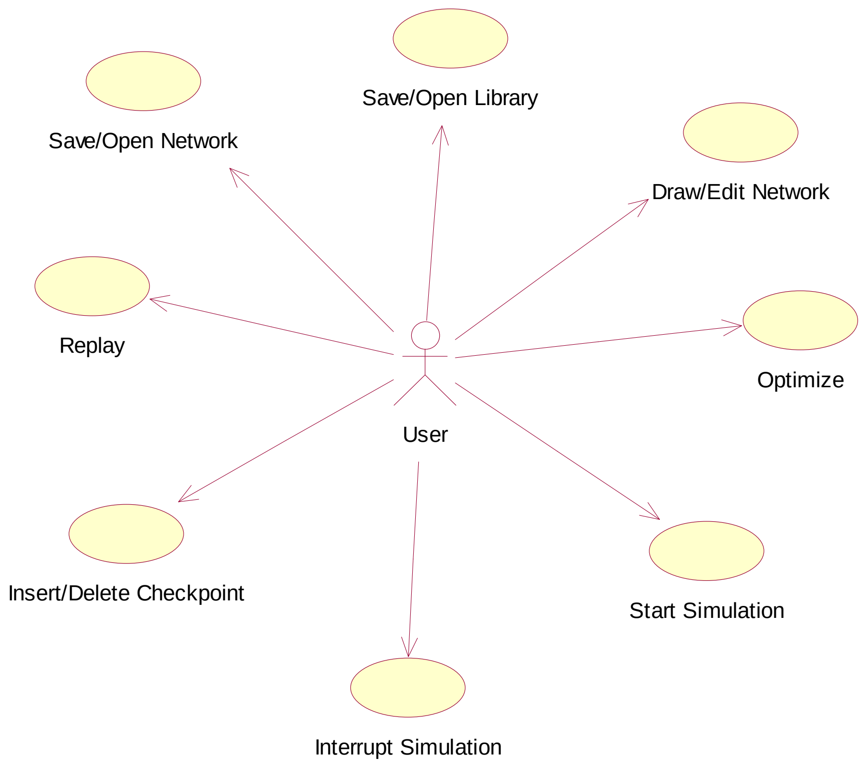
2.6 Product functions

a) The product shall provide a GUI with all the components needed to draw a complete pipeline system, a button to start the optimizer and a button to start the simulation.
b) The product shall provide an optimizer. The optimizer should be able to produce a job allocation that balances the load of each processor (that is, minimizes the load differences among cluster machines assigned to the simulation). The jobs are the pipelines components (pipes, joints, compressors …). Each job has some computation time and some communication time. The computation time depends on the characteristic of the component and the machine on which it is executed. The communication time depends on the amount of information exchanged and whether or not the connected component are on the same machine (local communication) or not (remote communication). Given these constraints, the optimizer will find an optimal distribution of jobs among machines that minimizes the workload of each processor.
c) The product shall integrate a simulator. The simulator should solve a set of partial differential equations that mathematically models the pressure and flow rate distribution in each component of the real pipeline system.

2.7 User characteristics

a) Users of the system should be experienced pipeline design engineers who have a good understanding of a pipeline system.
b) Users should be able to understand and manipulate pipeline characteristics.
c) No particular training should be necessary to use the software.

Following is the use case diagram for the software:



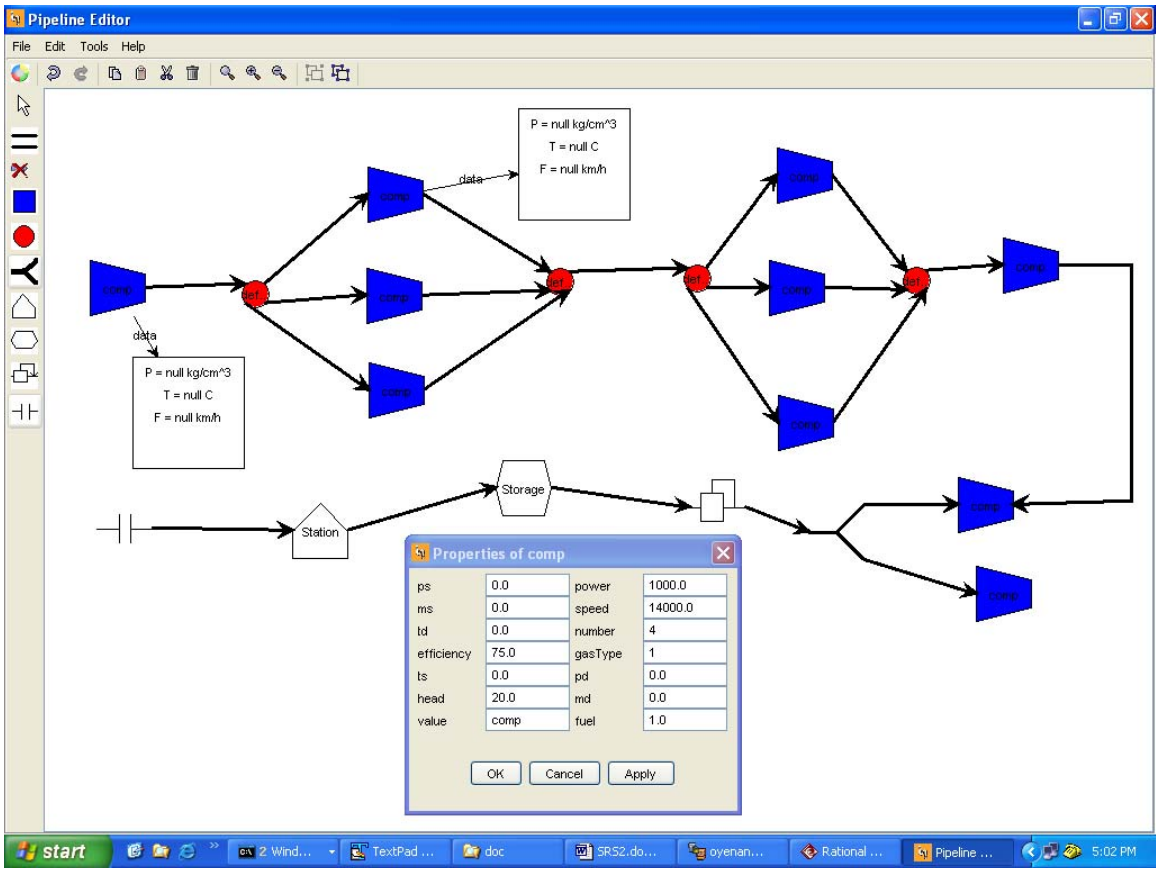
Virtual Pipeline Simulation System: Use Case

3. Specific requirements

3.1 External interface requirements

The interface provided will be the pipeline editor. It should be able to be started from any computer via a browser using Java WebStart. The interface should provide all the necessary components to draw a complete pipeline system. Characteristics of those components shall be defined at the time of their creation. As the pipeline system can be very large, the interface shall provide a way to save/retrieve previously built pipeline subsystems. The interface will consist of one window with 2 toolbars and one menu bar. The horizontal toolbar will have a button for the components and will support drag and drop to insert components. The vertical toolbar will contain all the buttons for editing and zooming. The menu bar will offer the same functionality as the 2 toolbars in addition of the save/open function. The interface will offer the possibility to use the keyboard via some shortcut keys.

Following is a screenshot of a prototype GUI:

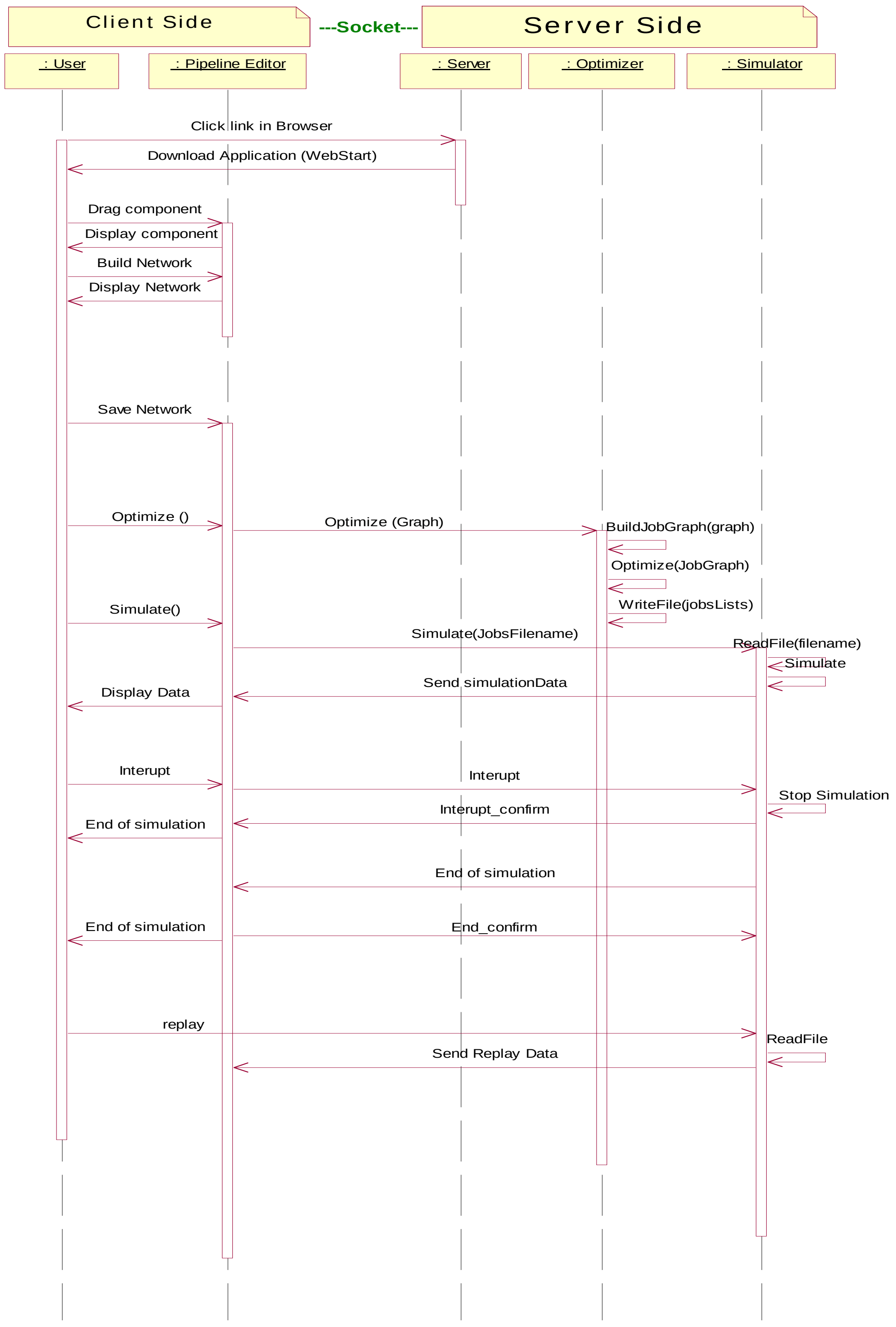


ps	0.0	power	1000.0
ms	0.0	speed	14000.0
td	0.0	number	4
efficiency	75.0	gasType	1
ts	0.0	pd	0.0
head	20.0	md	0.0
value	comp	fuel	1.0

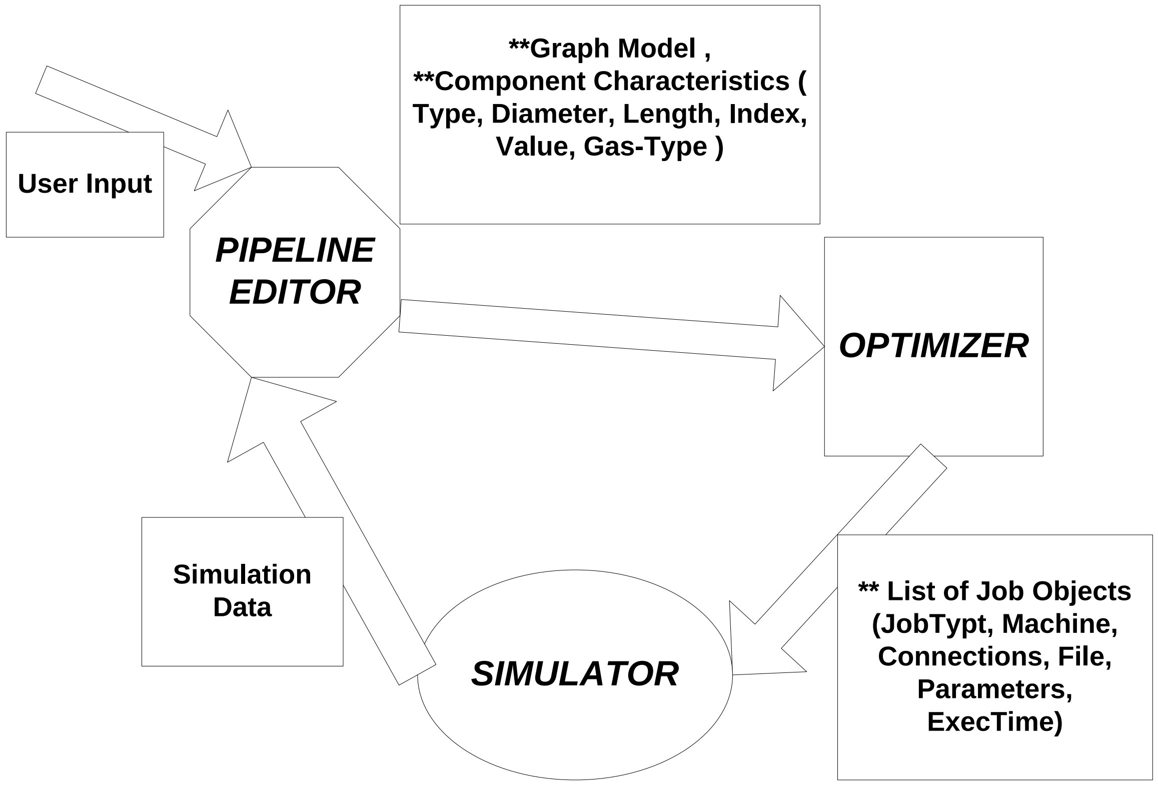
PIPELINE EDITOR

3.2 Functional requirements

In order to provide the most realistic and accurate simulation, the system should implement adequately every features of the pipeline simulation. Each feature presents some required conditions that the system should meet to react correctly.
The diagrams below show the sequence diagram and the interaction of the different parts of the software.



Sequence diagram of the Virtual Pipeline Simulation Testbed


**Graph Model ,
**Component Characteristics (Type, Diameter, Length, Index, Value, Gas-Type)
User Input
PIPELINE EDITOR
OPTIMIZER
Simulation Data
SIMULATOR
** List of Job Objects (JobTypt, Machine, Connections, File, Parameters, ExecTime)

<u>**Dataflow of the Virtual Pipeline Simulation Testbed**</u>

3.2.1 Pipeline Editor

Inputs: The input for the pipeline editor should come from the user. The user will define the components belonging to the pipeline system along with their characteristics.
Outputs: The pipeline editor shall produce a list of component objects. A component can be either a pipe or a compressor.

a. List of components

The GUI shall provide the following components: pipes, station, split, joint, orifice meter, storage, compressor, driver, regulator, receipt point, delivery point.
Following are the icons used in the GUI:

🟦	═	≺	⌂	⬭	⊣⊢	🔴
Compressor	Pipe	Split	Station	Storage	Orifice	Receipt

b. Draw a component

The user shall be able to draw any components needed for the pipeline system either by clicking on the component icon in the toolbar or by dragging it into the drawing pad.

a) Draw a compressor
A compressor shall only be connected to pipelines. It can accept several pipelines connections.

b) Draw a joint
A joint should be connected to at least two pipelines. Pipelines should be the only components connectable to joints.

c) Draw a pipe
Pipes should have another component connected at each end.

c. Delete a component

The user shall be able to delete any components in the pipeline system either by right-clicking on the component and selecting remove or by clicking on the remove icon in the toolbar or using the delete key.

d. Edit a component

The user shall be able to edit the characteristics of any components inside the pipeline system by using the right-click menu. Features available for editing should depend on the component selected.

e. Move a component

The user shall be able to move any components of the pipeline system inside the drawing space using a dragging move. All the components connected to the component moved should also move and stay connected.

f. Undo/Redo an action

The user shall be able to undo or redo any action done on any components of the pipeline system either by clicking on an icon in the toolbar. If there is no action to undo (or redo), the button should be disable.

g. Copy/Cut/Paste a component

The user shall be able to copy, cut or paste any components of the pipeline system using the buttons in the toolbar or the standard keyboard shortcuts.

h. Zoom in/Zoom out

The user shall be able to zoom in or zoom out any area of the pipeline system using the buttons in the toolbar.

i. Optimize

The user shall be able to launch the optimizer from the GUI by clicking on a button on the toolbar.

j. Simulate

The user shall be able to launch the simulation from the GUI by clicking on a button on the toolbar.

k. Insert a checkpoint

The user shall be able to launch insert a checkpoint at any time during the simulation.

l. Playback

The user shall be able to restart the simulation by providing a checkpoint from where the simulation should be restarted.

3.2.2 Optimizer

Input: A list of components objects
Output: A list of job objects. In addition to the fields of a component, a job has information about the machine on which it should be executed, the components connected to it, the execution time and the associated file containing the source code of its execution.

The job allocation optimization is a discrete optimization problem. The system will use the Branch and Bound algorithm to find the best distribution given some time and communication constraints. The solution may not be optimal but should be very close to the optimal one. The optimizer should adequately balance computation and communication time among all the processors. It should output a list of all jobs along with the machines on which they should be executed in order to have the best distribution.

3.2.3 Simulator

Input: A list of job objects
Output: A list of job object with their new property values.
The simulator should solve a set of partial differential equations to simulate the pressure and flow rate distribution in each component of the pipeline system. It should continuously output some values in order to visualize the current state of the simulation in the GUI.

3.3. Performance requirements

The system should be able to handle at least a set of 1000 jobs. The computation time should be kept minimal in both the optimizer and the simulator. The user should not wait more than 20 minutes to have the output of the optimizer and no more than 1 hour for the results of the simulator. The amount of data transferred should also be kept minimal to avoid too much communication overhead.

3.4. Software system attributes

a. Accuracy

Accuracy is the most important attribute for the virtual simulation pipeline testbed. The simulator must accurately model the pressure and the flow in each component of the pipeline system. If the convergence criteria are not well established, the simulation will be far from the real model.

b. Reusability

The system will have several releases with each time an increased number of functionality. Some new components and features will be added.

c. Maintainability

The system shall be separated into modules following the MVC (Model View Controller) pattern. There will be a module for the GUI, one for the optimizer and another one for the simulator.

d. Portability

The modules will be written in Java. As Java is supported on many platforms, it should be quite easy to move to another platform. For performance reasons, some parts will be written in some specific platform-dependant languages.

References
IEEE STD 830-1998, "IEEE Recommended Practice for Software Requirements Specifications". 1998 Edition, IEEE, 1998.
Dr. Scott Deloach's CIS748 lecture notes "http://www.cis.ksu.edu/~sdeloach/748"

CHAPTER 3: PROJECT PLAN

The project is divided into three phases, which are Specification phase, Design phase, and Implementation, Testing, and Documentation phase. Each of those three phases is ended by presentation at the end of the phase.

	Project Task	Duration (Days)	Start Date	End Date
Phase I: Specification				
1.	Background Study (JNI, Branch & Bound)	30	7/1/03	8/1/03
2.	Overview	1	9/20/03	9/21/03
3.	Optimizer prototype	30	8/1/03	9/1/03
4.	GUI Prototype	25	9/10/03	10/6/03
5.	Software Requirements Specification	1	9/24/03	9/25/03
6.	Project Plan	1	9/23/03	9/24/03
7.	Cost Estimation	1	9/25/03	9/26/03
8.	Software Quality Assurance Plan	1	9/26/03	9/27/03
9.	Documentation for Presentation 2	4	9/29/03	10/2/03
10.	Presentation 1			**10/3/03**
Phase II: Design				
11.	Develop Prototype	20	10/05/03	10/25/03
12.	Update SRS	1	11/03/03	11/04/03
13.	Update SQAP	1	11/04/03	11/05/03
14.	Test Plan	3	11/05/03	11/08/03
15.	Develop Implementation Plan	3	10/20/03	10/23/03
16.	Design	7	10/23/03	10/30/03
17.	Formal Technical Inspection	4	11/03/03	11/07/03
18.	Documentation for Presentation 2	2	11/07/03	11/09/03
19.	Presentation 2			**11/10/03**
Phase III: Implementation				
20.	Source Code	30	11/11/03	12/10/03
21.	Testing and Reliability Evaluation	2	12/1/03	12/3/03
22.	Create User Manual	5	12/3/03	12/8/03
23.	Project Evaluation	4	12/5/03	12/9/03
24.	Project Document	10	12/3/03	12/13/03
25.	Documentation for Presentation 3	9	12/3/03	12/11/03
26.	Presentation 3			**12/12/03**

CHAPTER 4: COST ESTIMATE

I- Function Point Analysis :

A function point analysis is a method of calculation lines of code using function points. A function point is a rough estimate of a unit of delivered functionality of a software project. To calculate the number of function points for a software project all the user inputs, user outputs, user inquiries, number of files and number of external interfaces are counted and divided into three categories: low, average and high.

- **Number of user inputs**
  Each user input that provides distinct application oriented data to the software is counted.
  - Drag a component
  - Delete a component
  - Change properties of a component
  - Display data of a component
  - Insert a pipe
  - Save/Open Graph
  - Save/Load Library
  - Create a station
  - Remove a station
  - Unfold a station
  - Fold a station
  - Undo/Redo action
  - Copy/Cut/Paste a component
  - Zoom in/Zoom out.
  - Optimize
  - Start Simulation
  - Stop Simulation
  - Start Replay
  - Stop replay

- **Number of user outputs**
  Each user output that provides application oriented information to the user is counted. In this context "output" refers to reports, screens, error messages, etc. Each user input has a corresponding output. In addition some error messages can occur:
  - Bad station selection

  - Bad library file
  - Bad graph file
  - No optimization file
  - No simulation file
  - Graph not saved

- **Number of user inquiries**
  An inquiry is defined as an on-line input that results in the generation of some immediate software response in the form of an on-line output. There are no inquiries in this software.

- **Number of internal files**
  Each logical file generated by the program is counted. Here there are 4 types of files:
  - Graph files.
  - Library files.
  - Optimizer files.
  - Simulator files.

- **Number of external interfaces file**

The external interface file is an internal logical file for another application.
  - Optimizer files
  - Simulator files

Each of these five major components is rated as low, average or high depending on the number of files referenced and the number of data elements.
A score is attributed to each rating level.

External Input:
Number of data elements: 19
Number of file referenced: 2
Rating: High
Score: 6

External Output:
Number of data elements: 25
Number of file referenced: 0
Rating: Ave
Score: 5

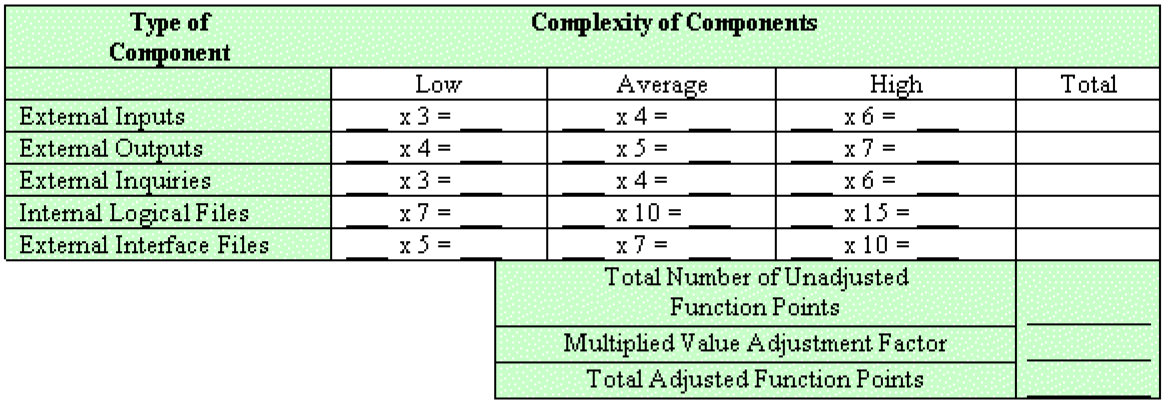
External Inquiries:
Number of data elements: 0

Number of file referenced: 0
Rating: N/A
Score: 0

Internal files:
Number of data elements: 4
Number of user data referenced: 4
Rating: Low
Score: 7

External Files:
Number of data elements: 2
Number of user data referenced: 4
Rating: Low
Score: 5

The following table gives the formula to compute the total unadjusted function point.



Type of Component	Complexity of Components			
	Low	Average	High	Total
External Inputs	___ x 3 = ___	___ x 4 = ___	___ x 6 = ___	
External Outputs	___ x 4 = ___	___ x 5 = ___	___ x 7 = ___	
External Inquiries	___ x 3 = ___	___ x 4 = ___	___ x 6 = ___	
Internal Logical Files	___ x 7 = ___	___ x 10 = ___	___ x 15 = ___	
External Interface Files	___ x 5 = ___	___ x 7 = ___	___ x 10 = ___	
		Total Number of Unadjusted Function Points		________
		Multiplied Value Adjustment Factor		________
		Total Adjusted Function Points		________

Total Unadjusted Function Points: 6x6+5x5+7x15+5x10 = 216

Total Function Points = Total Unadjusted Function Points x [0.65 + 0.01 x SUM(F_i)] where SUM(F_i) counts the technical complexity. It is generated by giving a rate on a scale of 0 to 5 for each of the following questions. The higher the rate the more important the function is.

		Scale
1	Does the system require reliable backup and recovery?	0
2	Are data communications required?	5
3	Are there distributed processing functions?	5

4	Is performance critical?	3
5	Will the system run in an existing, heavily utilized operational environment?	2
6	Does the system require on-line data entry?	0
7	Does the on-line data entry require the input transaction to be built over multiple screens or operations?	0
8	Are the files updated online?	3
9	Are the input, outputs, files or inquiries complex?	4
10	Is the internal processing complex?	5
11	Is the code designed to be reusable?	2
12	Are conversions and installation included in the design?	0
13	Is the system designed for multiple installations in different organizations?	0
14	Is the application designed to facilitate change and ease of use by the user?	0
	Total value adjustment factor	**29**

Total function points = 216 * [0.65 + 0.01 * 29] = **203.04**

We select the language factor for applications written in JAVA to be 40.

The language factor here is an assumed value. It is expected that the language factor for 3rd generation language to lie between 20 and 60. since no code is automatically generated by an IDE but there will be some code reused, the language factor is assumed to be average.

Therefore the estimated source lines of code =

Total Function points * language factor = 203.04 x 40 = 8121 LOC

II- Cost Analysis Using COCOMO

The COCOMO model is a good measure for estimating the number of person-months and the time required to develop software. The Virtual Pipeline Simulation Testbed can be considered as an organic mode process (in-house, flexible with less-complex development). The basic effort and schedule estimating formula is:

$\text{Effort} = 3.2\ \text{EAF}\ (\text{Size})^{1.05}$;
$\text{Time} = 2.5\ (\text{Effort})^{0.38}$;

Where:
Effort = number of staff-months
EAF = Effort Adjustment Factor (cf. Table)
Size = number of delivered source instructions (in thousands of lines of code)

The following table gives the value of the efforts multipliers. The product of those 15 factors will give the value of the EAF for the given project.

Cost Driver	**Description**	**Rating**					
		Very Low	**Low**	**Nominal**	**High**	**Very High**	**Extra High**
Product							
RELY	Required software reliability	0.75	0.88	1.00	1.15	1.40	-
DATA	Database size	-	0.94	1.00	1.08	1.16	-
CPLX	Product complexity	0.70	0.85	1.00	1.15	1.30	1.65
Computer							
TIME	Execution time constraint	-	-	1.00	1.11	1.30	1.66
STOR	Main storage constraint	-	-	1.00	1.06	1.21	1.56
VIRT	Virtual machine volatility	-	0.87	1.00	1.15	1.30	-
TURN	Computer turnaround time	-	0.87	1.00	1.07	1.15	-
Personnel							
ACAP	Analyst capability	1.46	1.19	1.00	0.86	0.71	-
AEXP	Applications experience	1.29	1.13	1.00	0.91	0.82	-
PCAP	Programmer capability	1.42	1.17	1.00	0.86	0.70	-
VEXP	Virtual machine experience	1.21	1.10	1.00	0.90	-	-
LEXP	Language experience	1.14	1.07	1.00	0.95	-	-
Project							
MODP	Modern programming practices	1.24	1.10	1.00	0.91	0.82	-

TOOL	Software Tools	1.24	1.10	1.00	0.91	0.83	-
SCED	Development Schedule	1.23	1.08	1.00	1.04	1.10	-

Table 2-1. Software Development Effort Multipliers (EAF)

- EAF = 0.75 x 0.94 x 1.15 x 1.00 x 1.00 x 0.87 x 0.87 x 0.71 x 0.82 x 0.70 x 0.90 x 0.95 x 0.82 x 0.91 x 1.10 = 0.17
- KLOC = 8 (8,000 SLOC) (Estimation)
- E = 3.2 x 0.17 x $8^{1.05}$ = 4.82 staff-month
- Time = 2.5 x $4.82^{0.38}$ = 4.54 months

Analysis:
1 staff-month = 152 hours
=> Total Time = 3326 Hours

References:
- "Software Cost Estimation: Metrics and Models". Kim Johnson http://sern.ucalgary.ca/courses/seng/621/W98/johnsonk/cost.htm.
- "An Introduction to Function Point Analysis", http://www.qpmg.com/fp-intro.htm
- David Longstreet, "Fundamentals of Function Point Analysis", http://www.ifpug.com/fpafund.htm

CHAPTER 5: Architecture Elaboration Plan

The purpose of this document, as required by the MSE portfolio requirement, is to define the activities and actions that must be accomplished prior to the Architecture Presentation.

The activities and actions to be accomplished prior to the architecture presentation are listed below:

- Software Requirement Specification.
- Software Quality Assurance plan
- The Engineering Notebook
- The vision document
- The Cost Estimation
- The Project plan
- The Implementation Plan

The artifacts that will undergo formal technical inspection are:

- Object model
- The requirement specification

The Formal Technical Inspection will follow an IEEE standard formal checklist and will be led by two MSE students and one student involved in the project:

1. Padmaja Havaldar
2. Sudarshan Kodwani
3. Liubo Chen

The inspectors will provide a well-documented report on the result of their inspection.

References:
http://www.cis.ksu.edu/~sdeloach/748/protected/slides/748-4-formal-inspections.pdf

CHAPTER 6: Software Quality Assurance Plan

1. **Purpose**

The software item covered by this SQAP is the ‘Virtual Pipeline Simulation Testbed’. The system is used to simulate the pressure ad the flow in the components of a real pipeline system. This SQAP covers the entire life cycle of the software.

2. **Management**

2.1 Organization

A committee of three professors will supervise the project. Only one developer will implement the project. The committee consists of:

- Dr. Virgil Wallentine (Major Professor)
- Dr. Masaaki Mizuno
- Dr. Daniel Andresen.

The developer is Walamitien Oyenan.
The committee will approve the design and requirements and will be responsible for monitoring implementation progress.

2.2 Tasks

The following tasks will be completed for the project:

- Requirements Specification
- Cost Estimation
- Project Planning
- Formal Specification & Verification
- Test Planning
- Design Documentation
- Project Presentations
- Inspections
- Implementation
- Testing & Verification
- Documentation
- Project Evaluation

2.3 Roles and Responsibilities

The developer will be responsible for all the tasks described above. He will be under the supervision of the major professor and will report to all the committee members in the form of three presentations.

3. Documentation

3.1 Purpose

To ensure the quality of the Virtual Pipeline Simulation Testbed, as a minimum, the Software Quality Assurance will use the Software Design Document (SDD), the Software Requirement Specification (SRS), the Test Plan, the Formal Specification and the User Documentation for verifying and validating the product.

3.2 Minimum documentation requirements

3.2.1 Software requirements specification

The SRS lists the requirements of a system and it should correctly describe the system requirements. It specifies the functionality and performance of the project in terms of speed, reliability etc. It describes how the system interacts with the people using it and specifies the design constraints and standards to be followed.

3.2.2 Software Test Plan

The purpose of this document will be to develop and record formal procedures for the verification and validation of the pipeline simulation software.

3.2.3 Formal Software Specification

A section of the software will be formally specified using a formal specification tool.

3.2.4 Software design document

This document describes the overall structure of the software. It will contain an object model constructed using rational rose. The object model will describe the various classes used in the project.

3.2.5 User Documentation

The user documentation will consist of a user manual, which will identify the features of the software and their functions. It will also describe all error messages and program limitations and constraints. The user documentation will also contain source code.

4. Standards, practices, conventions, and metric

4.1 Purpose

This section identifies the standards, practices, conventions, and metrics to be used in the virtual pipeline simulation system and states how the compliance will be monitored and assured.

4.2 Content

The MSE project portfolio will serve as a guideline in developing the documents.

4.2.1 Documentation Standards

The Software Requirements Specifications (SRS) and SQA Plan (SQA) will be based upon IEEE Software Engineering Standards.

4.2.2 Coding Standards

The source code will follow the guidelines in the Java coding standards.

4.2.3 Metrics

The COCOMO model will be used to estimate the effort and time needed for the development of the software.

5. Reviews and Audits

5.1 Purpose

This section defines the technical and managerial reviews to be performed, and states how they are to be accomplished.

5.2 Minimum Requirements

A number of reviews will be done during the design, development, and testing of the project. They will be under the supervision of the committee. The following reviews will be conducted:

- Software Requirements Review
- Preliminary Design Review
- Formal Technical Inspection

In addition, there will be three formal presentations at the end of each phase of development as describe on the project plan.

6. Testing and Verification

To insure that the Virtual pipeline system meets the required quality, some tests have to be performed during the development process. The system must satisfy the standard functional requirements for the gasoline pump system stated in the SRS. The system should also satisfy the others criteria as stated in the SRS: performance, accuracy, reusability, maintainability and portability.

7. Problem reporting and corrective action

All problems that cannot be resolved by the developer will be reported to the major professor. The committee will provide reviews on all current work and corrective measures for changes will be taken. The errors and problems encountered during the development of the project will be documented.

8. Tools, techniques, and methodologies

The project will use the JGraph3.0 library along with Swing to build the Pipeline Editor (GUI). Rational Rose will be used to visually design the software being developed. Alloy or OCL will be used as a formal specification tool.

References

"IEEE guide for software quality assurance planning" IEEE Std-730.1-1995
Pressman, Roger S. "Software Engineering: A Practitioner's Approach". Fifth Edition, Mc GrawHill, NY, June, 2001.

CHAPTER 7: Architecture Design

1. System Design Description

This document contains the complete architectural design of the GUI and the Optimizer of the Virtual Pipeline Simulation Testbed. The GUI is built as an extension of the JGraph and Swing packages. In order to have a better understanding of the design, this document will briefly describe the design and features of JGraph before explaining in details the design of the GUI and the Optimizer. The complete design of JGraph can be found online (cf. references).

There are 3 main packages in this architecture:

- Jgraph
- Editor
- Optimizer

The design of each package will be explained separately in the rest of this document.

2. JGraph design

The implementation of JGraph is entirely based on the source code of the JTree class. However, it is not an extension of JTree; it is a modification of JTree's source code. The components for trees and lists are mostly used to display data structures, whereas this graph component is typically also used to modify a graph, and handle these modifications in an application-dependent way.

2.1 - Features

The main features of JGraph are:

- **Inheritance**: JTree's implementation of pluggable look and feel support and serialization is used without changes. The UI-delegate implements the current look and feel, and serialization is based on the Serializable interface, and XMLEncoder and XMLDecoder classes for long-term serialization.

- **Modification:** The existing implementation of in-place editing and rendering was modified to work with multiple cell types.
- **Extension:** JGraph's marquee selection and stepping-into groups extend JTree's selection model.

- **Enhancement:** JGraph is enhanced with datatransfer, attributes and history, which are Swing standards not used in `JTree`.

- **Implementation:** The layering, grouping, handles, cloning, zoom, ports and grid are new features, which are standards-compliant with respect to architecture, and coding conventions.

2.2 - The Model

The model provides the data for the graph, consisting of the cells, which may be vertices, edges or ports, and the connectivity information, which is defined using ports that make up an edge's source or target. This connectivity information is referred to as the graph structure. (The geometric pattern is not considered part of this graph structure.)

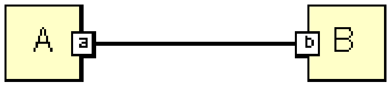


Figure 1. A graph with two vertices and ports, and one edge in between

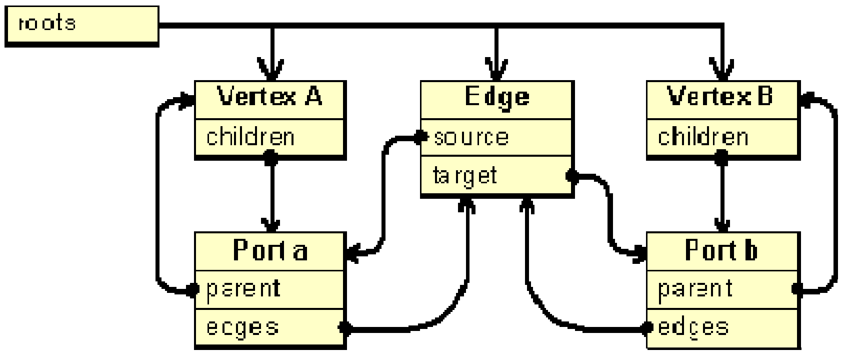


Figure 2. Representation of the graph in the DefaultGraphModel

2.3 - The View

The view in JGraph is somewhat different from other classes in Swing that carry the term view in their names. The difference is that JGraph's view is stateful, which means it contains information that is solely stored in the view. The GraphLayoutCache object and the CellView instances make up the view of a graph, which has an internal representation of the graph's model.

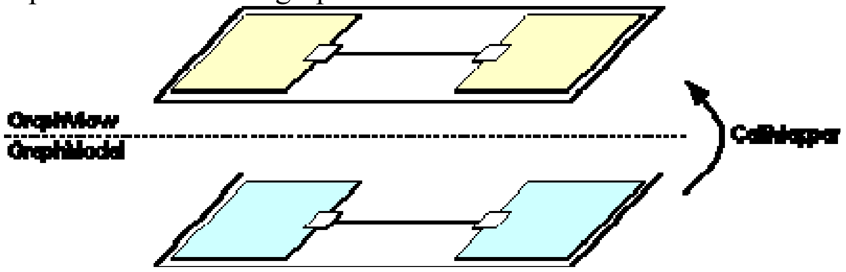


Figure 3. GraphLayoutCache and GraphModel

The GraphLayoutCache object holds the cell views, namely one for each cell in the model. The graph view also has a reference to a hash table, which is used to provide a mapping from cells to cell views.

2.4 - The control

The control defines the mapping from user events to methods of the graph- and selection model and the view. It is implemented in a platform-dependent way in the UI-delegate, and basically deals with in-place editing, cell handling, and updating the display. As the only object that is exchanged when the look and feel changes, the UI-delegate also specifies the look and feel specific part of the rendering.

In JGraph, the graph model, selection model and graph view may dispatch events. The events dispatched by the model may be categorized into:

- Change notification
- History support

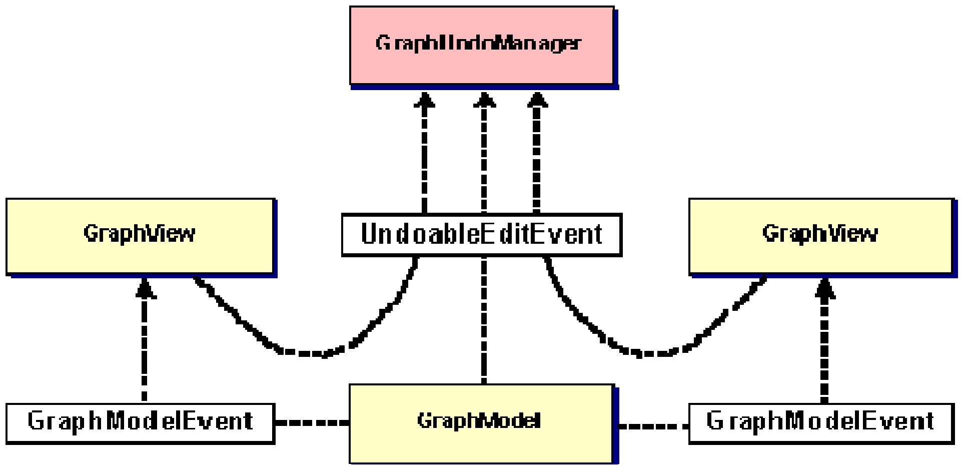


Figure 4. JGraph's event model

The GraphModelListener interface is used to update the view and repaint the graph, and the UndoableEditListener interface to update the history. These listeners may be registered or removed using the respective methods on the model.

The selection model dispatches GraphSelectionEvents to the GraphSelectionListeners that have been registered with it, for example to update the display with the current selection. The view's event model is based on the Observer and Observable class to repaint the graph, and also provides undo-support, which uses the graph model's implementation.

3. Pipeline Editor Design

Most of the classes of the Pipeline Editor extend the classes of JGraph in order to provide a custom graph needed to draw the pipeline network. Only a few classes directly extend some Swing classes. The features implemented by the pipeline editor are described in the Software Requirement Specification document.

3.1 - Class diagram

Following is the class diagram of the pipeline editor:

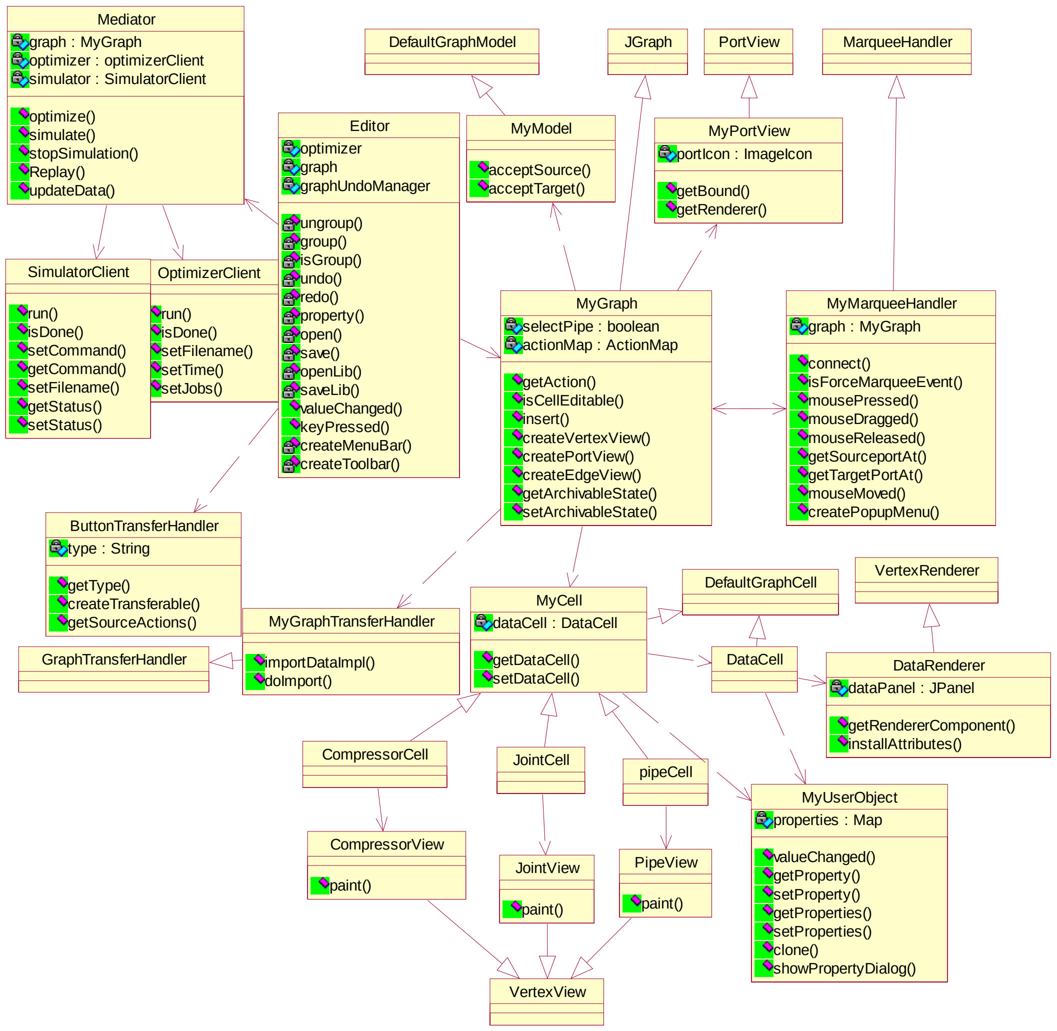


Figure 5: Class Diagram of the Pipeline Editor

3.2 - Class description

This section describes each class of the pipeline editor and its function. For the classes extending JGraph classes, only the purpose of the extension is explained. To understand the whole function of the class, it is necessary to refer to the extended class in the JGraph package.

Class Editor extends JPanel:
This is the main class representing the main panel of the application. It has the graph panel (instance of JGraph) and the toolbars.

Class MyGraph extends JGraph:
Provide a custom graph model.
Contains all the necessary methods to create and insert custom components in the graph.

Class MyMarqueeTransferHandler extends MarqueeTransferHander:
Provide a custom mouse handler for the graph.
Provide custom edges used to represent pipes.
Create popup dialogs.

Class MyModel extends GraphModel:
Define the criteria to accept the connection edge (pipe) and cell (component)

Class MyPortView extends Port view:
Define a custom representation of ports.

Class MyGraphTransferHandler extends GraphTransferHandler:
Provide drag and drop support for the graph.

Class ButtonTransferHandler extends TransferHandler:
Transfer Handler for dragging the buttons from the toolbar.

Class DataCell extends DefaultGraphCell:
Define a cell use to display data from the simulation.
This cell is a JPanel.

Class DataRenderer extends VertexRenderer:
Use to render the DataCell as a JPanel containing information to be displayed.

Class MyCell extends DefaultGraphCell:
Abstract class for all the custom cells representing the components.
Each MyCell object has a reference to a DataCell.

Class CompressorCell extends MyCell:
Represent a component cell. The component is a compressor.
Each component cell has a DataCell and a MyUserObject to holds information about the cell.
There is similar class for each component (Pipe, Joint, Split …).

Class CompressorView extends VertexView:

Define the shape of the component.
There is similar class for each component (Pipe, Joint, Split …).

Class MyUserObject extends Object:
Holds the property of the associated object (component) in a map for future reference.
Display the property dialog for each component.

Class SaveServer:
Server to save the user file on the server side.
Receive the file via socket and save it.

Class SaveClient:
Send the file to be saved to the server via socket.

Class Optimizer:
Create JobComponent objects from component cells taken from the graph.
Each component cell has a corresponding JobCcomponent.
Holds a reference to BranchBound class to start the optimization.

4. Optimizer Design

Problem: Given a set of jobs with execution time and computation time and a set of machines, find the optimal job distribution among those machines. That is, find the distribution that minimizes the differences in the load of each machine.

4.1 - Depth-First Branch and Bound

Each job j has a computation weight Wj and a communication time Cj (sum of each communication time with all neighbors).

The objective is to minimize the load on the busiest machine.

At each node, we consider a cost function for the busiest machine only (worst-case estimate).

A vertex in the tree represents a partial/complete allocation of jobs on machines.
The root of the search tree is the empty allocation.
A vertex at level k in the tree represents an assignment of jobs {J1,…,Jk}.

a) Cost function

The cost function f(x) is defined by:

f(x) = g(x) + h(x) ;

where:

g(x) : actual cost for the current allocation.

h(x) : load contribution on the busiest machine of the next job to be allocated.

We have:

- $g(x) = \sum(Wj+Cj)$ for all j allocated to the busiest machine.
  Note: Cj consider only the communication with neighbors already allocated.

- $h(x) = \min(Wi, Ci)$, i being the next job to be allocated.

The heuristic function h(x) is explained as follows:

*If job i is eventually assigned on the busiest machine, its contribution to this node's load is just its weight.

*If job i is eventually allocated on some other machine, its contribution to the node's load is its communication time.

At each step, we want the take the case that minimize h(x).

b) Pseudo Algorithm:

```
  minCost = infinity,
  root = empty allocation,
  cost(root) = 0
   stack = allJobs
While stack not empty do
        node = dequeue stack
        if node isLeaf, update minCost
        else
          compute cost(node)
          if cost(node) > minCost then prune node
          else generate job allocation of all children of node
          end if
        end if
end while
return minCost
```

The following figure shows an execution of the Branch and Bound algorithm with 3 tasks (T1, T2, T3) and 2 processors (N1, N2) without and with pruning (Fig 7, 8).

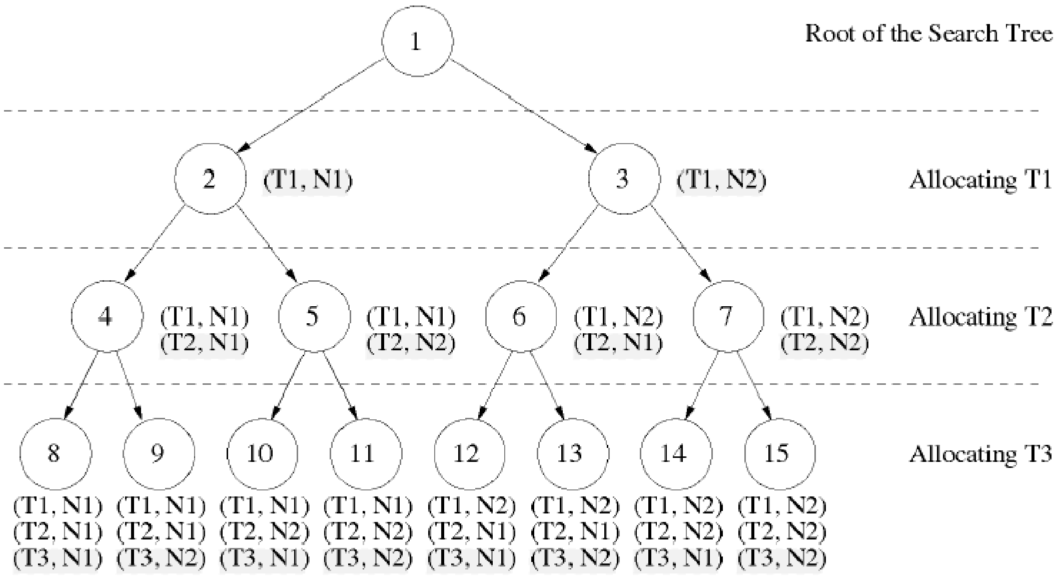

Root of the Search Tree
Allocating T1
Allocating T2
Allocating T3
1
2 (T1, N1)
3 (T1, N2)
4 (T1, N1) (T2, N1)
5 (T1, N1) (T2, N2)
6 (T1, N2) (T2, N1)
7 (T1, N2) (T2, N2)
8 (T1, N1) (T2, N1) (T3, N1)
9 (T1, N1) (T2, N1) (T3, N2)
10 (T1, N1) (T2, N2) (T3, N1)
11 (T1, N1) (T2, N2) (T3, N2)
12 (T1, N2) (T2, N1) (T3, N1)
13 (T1, N2) (T2, N1) (T3, N2)
14 (T1, N2) (T2, N2) (T3, N1)
15 (T1, N2) (T2, N2) (T3, N2)

Fig. 6: Example with 3 tasks(T1, T2, T3) and 2 processors (N1, N2) without pruning

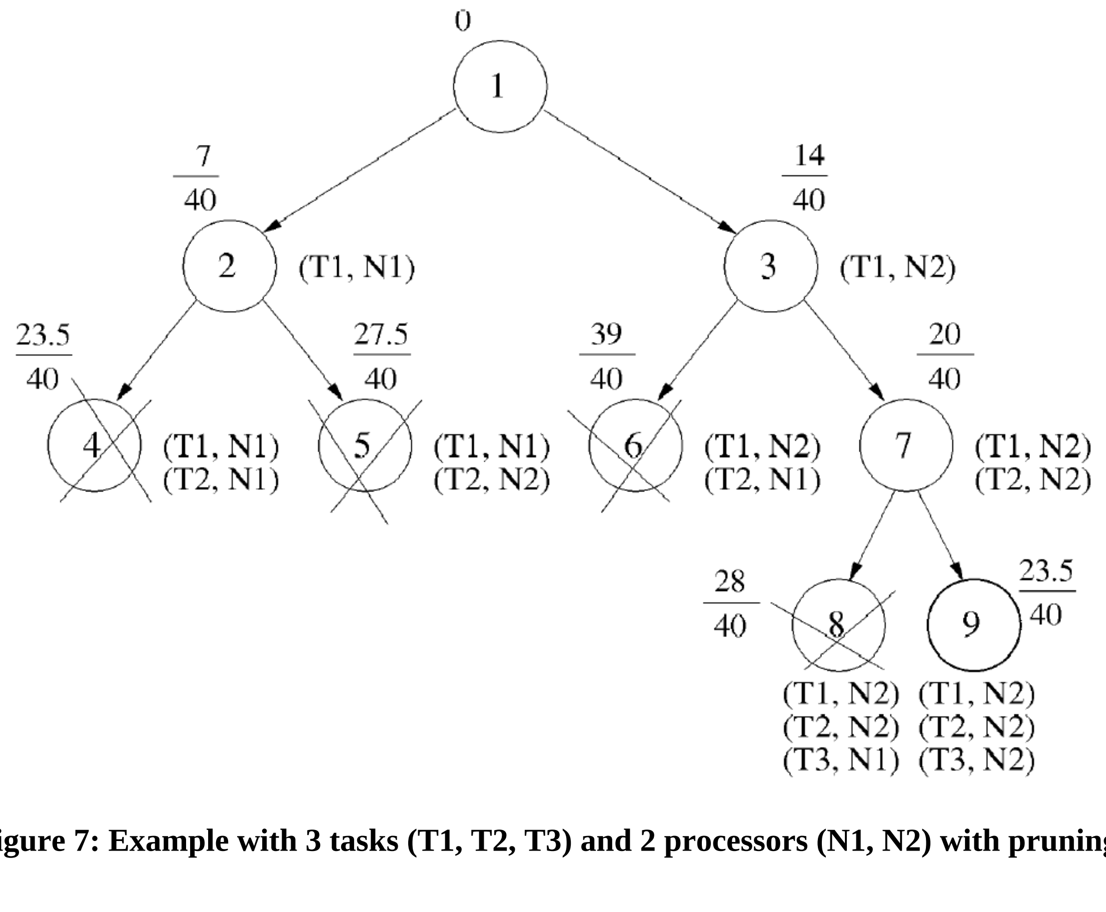


Figure 7: Example with 3 tasks (T1, T2, T3) and 2 processors (N1, N2) with pruning

c) Shared Version

In the shared version, the sequential algorithm is started. When there are enough nodes, the nodes are distributed among workers. Each worker can the start its own branch and bound algorithm. Every time a new bound is reached, it is compared to the shared bound and updated if necessary. At the end, the shared bound, which is the minimal found, will be associated to a solution object (containing the minimal allocation). This solution Object will be returned.

4.2 - Class Diagram

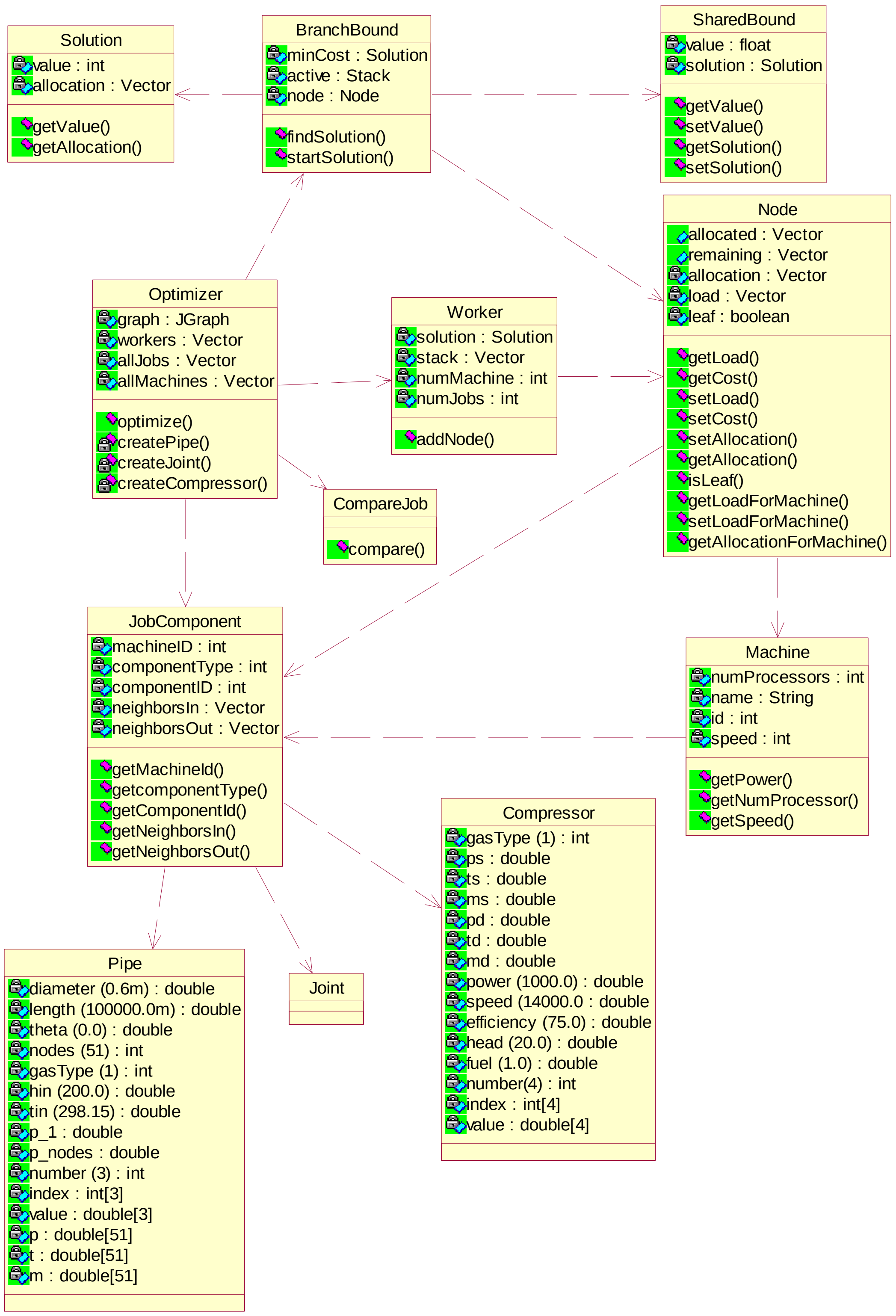


Figure 9: Class Diagram of the Optimizer

4.3 - Class Description

Class BranchBound
Implement the branch and bound algorithm.
Holds a reference to the current solution found.

Class Solution
Represent a solution to the Branch and Bound algorithm.
Contains the minimal allocation found.

Class Node
Holds the current allocation. The allocation can be partial (non-leaf node) or complete (leaf node).
For a non leaf node, jobs non allocated yet are stored inside the node.
An allocation is an array of machine with their corresponding jobs.

Class Machine
Holds all the information about a machine.
Store all the jobs allocated to this machine so far.

Class JobComponent
Abstract class representing a job. Sub classes of this class are component objects (pipe, compressor, joint…) .

Class Pipe extend JobComponent
Holds all the properties and initial values of a pipe.
There is a similar class for all components (Compressor, Joint, split…).

Class Worker extends Thread
Worker objects are threads searching a part of the tree.
They exchange new bounds via a shared memory (class SharedBound).
Holds a stack of nodes representing their part of the tree.

Class SharedBound
Holds the minimal bound found so far by the Worker objects.
Also holds the allocation (Solution object) corresponding to this bound.

Class CompareJob
Used to specify how jobs should be compared.
When the jobs are sorted, it helps reducing the number of nodes visited to reach the solution.
Jobs are compared by number of neighbors and by weight.

References:

- Gaudenz Alder, Design and Implementation of the JGraph Swing Component
http://www.jgraph.com/documentation.shtml

- Dar-Tzen et al., Assignement and Scheduling Communicating Periodic Tasks in Distributed Real-Time Systems, IEEE Transactions on Parallel and Distributed Systems, 1997

CHAPTER 8: Formal Requirement Specification

Introduction

This document specifies the protocol between the GUI on the client side and the simulator on the server side.

Specification

The GUI needs to be able to listen to the simulator in order to get the data from the simulation. When the user wants to start a simulation, he needs to pass a filename to the simulator. If this filename is not valid, an error code is returned. If it is a valid filename (the file exists and has the proper format), then the GUI is ready to accept data from the server. As long as there is some data available, the server continues to send them. At any time, the user can interrupt the simulation. A message is then sent to the simulator. The protocol will make sure that there is no loss of data due to interruption. The server can also send an end message when the simulation reaches the end. At the end (either by interruption, or normal termination), both the server and the GUI should be ready to start the protocol again.

Verification

The protocol is specified using Promela and checked with Spin. We want to check that the protocol has no deadlock. We also want to be able to verify that there are no unexpected messages. (E.g. a data message when expecting an end message).
Following are the FSMs used to derive the Spin Model:

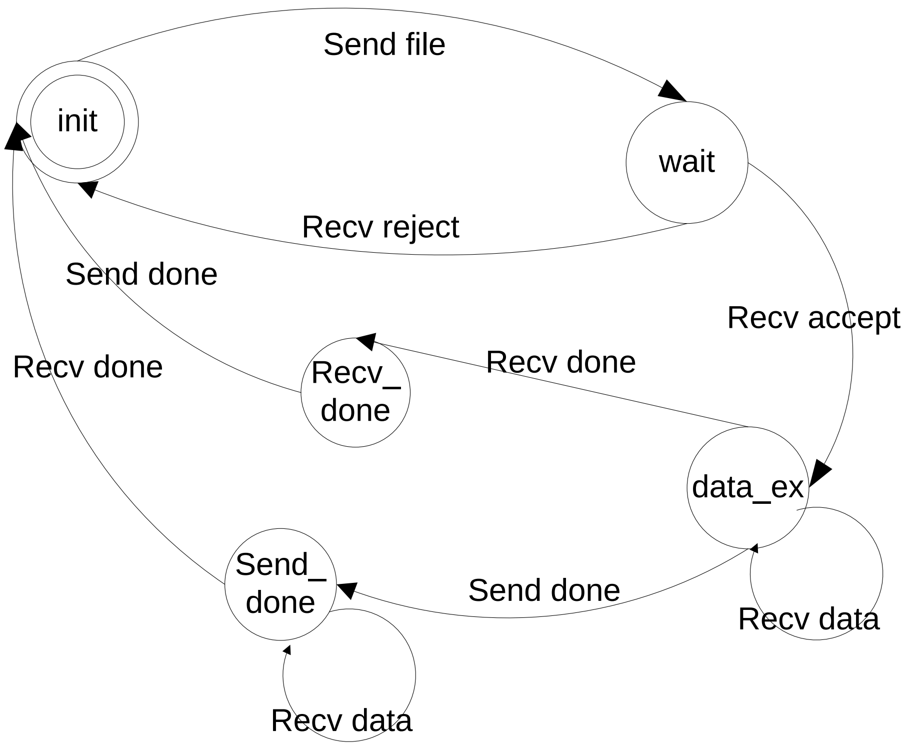


Figure 1: FSM for the GUI

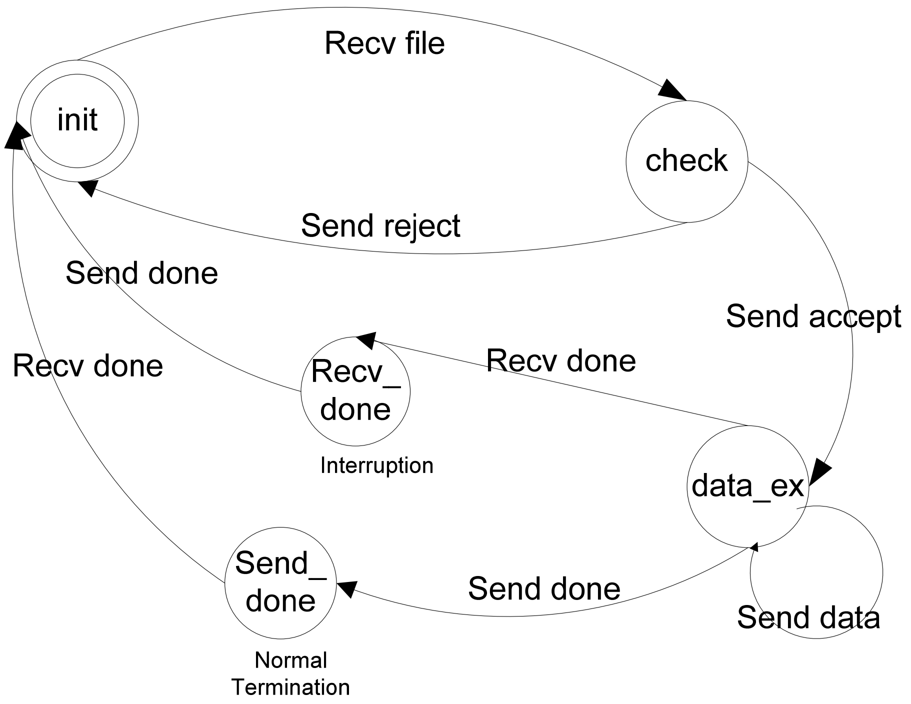


Figure 2: FSM for the Simulator

SPIN Model:

```
/*   Protocol GUI -  Simulator
 *   Virtual Pipeline Simulation Testbed
 *
 *   Walamitien OYENAN
 */

#define idle 0
#define wait 1
#define check 2
#define data_ex 3
#define recv_done 4
#define send_done 5


#define MAX 4

int datasent = 0;
mtype = {file, reject, accept, data, done}

chan socket1 = [MAX] of {mtype}
chan socket2 = [MAX] of {mtype}



proctype gui (chan send, recv) {
  int state = idle;

end:
  do
    :: atomic { state == idle ->
            send ! file;
            state = wait;
      }
    :: atomic { recv ? reject ->
        assert (state == wait);
        state = idle
      }
    :: atomic { recv ? accept ->
        assert (state == wait);
        state = data_ex;

      }
    :: atomic { recv ? data ->
        assert (state == data_ex || state == send_done);
        skip;
      }
    :: atomic { recv ? done ->
         assert (state == data_ex || state == send_done);
            if
          :: state == data_ex ->
            state = recv_done;
          :: state == send_done ->
            state = idle;
        fi
      }
    :: atomic { state == data_ex ->
        send ! done;
        state = send_done;
      }

    :: atomic { state == recv_done ->
            send ! done;
            state = idle;
      }
  od
}


proctype simulator(chan send, recv)
{
  int state = idle;

end:
  do
    :: atomic { state == idle ->
            recv ? file;
            state = check;
      }
    :: atomic { state == check ->
            send ! reject;
        state = idle
      }
    :: atomic { state == check ->
            send ! accept;
        state = data_ex;

      }
    :: atomic { recv ? done ->
      assert (state == data_ex || state == send_done);
            if
            :: state == data_ex ->
                    state = recv_done;
            :: state == send_done ->
                    state = idle;
            fi
      }
    :: atomic { state == data_ex ->
        if
             :: datasent < MAX ->
               send ! data;
               datasent++
             :: else ->
               send ! done;
               state = send_done;
            fi
      }

      :: atomic { state == recv_done ->
             send ! done;
             state = idle;
      }

  od
}


init {
  atomic {
    run gui(socket1,socket2);
    run simulator(socket2, socket1);
  }
}
```

SPIN Output:

```
(Spin Version 3.4.16 -- 2 June 2002)
        + Partial Order Reduction

Full statespace search for:
        never-claim             - (not selected)
        assertion violations    +
        cycle checks            - (disabled by -DSAFETY)
        invalid endstates       +

State-vector 56 byte, depth reached 53, errors: 0
    162 states, stored
    152 states, matched
    314 transitions (= stored+matched)
    330 atomic steps
hash conflicts: 0 (resolved)
(max size 2^19 states)

2.542   memory usage (Mbyte)
```

Reference:

"Spin Online References", http://spinroot.com/spin/Man/index.html

CHAPTER 9: Test Plan

1. Introduction

The Software Test Plan (STP) describes the plans for testing the software. The purpose of the test plan is to ensure that the intended functionalities are implemented properly. To fulfill this objective, a series of test will be executed during the implementation.

2. Scope

This plan will address only those items and elements that are related to the GUI and the Optimizer of the Virtual pipeline Simulation Testbed. The primary focus of this plan is to ensure that the GUI provides the appropriate functionalities and that the optimizer produces an optimal solution.

The project will have three levels of testing, Unit, System/Integration and Acceptance. Unit testing focuses verification effort on the major functions, and integration testing tests the program structures built with unit-tested modules. The details for each level are address in the approach section and will be further defined in the level specific plans.

3. Test Item

These are the items to be tested:

- Pipeline Editor
- Optimizer

4. Features to be Tested

- Pipeline Editor functions
- Optimizer performance
- Communication GUI – Optimizer
- Communication GUI - Simulator

5. Approach

5.1. Unit Testing

There will be mainly two units: the GUI unit and the Optimizer unit. All the classes will be tested in the unit they refer to. Classes belonging to both units (JobComponent and subclasses) will be tested only in the GUI unit.

5.2. Integration testing

Once the individual units have passed unit testing those units may then be used in integration testing. During integration testing, the units will be incorporated together and tested, adding one unit at a time. Integration testing will put together the GUI unit and the Optimizer unit.

6. Test Cases

6.1. Unit Tests

Pipeline Editor–

- Given a network, all operations as define in the Software Requirement Specification should produce the expected result.
- Drawing a network should meet all the requirements as defined in the Software Requirement Specification document.

Optimizer –

- Given a set of jobs and machines, it should produce the correct output.
- Will have the capability to produce an optimal solution with at least 1000 jobs.

6.2. Integration Tests

GUI-Optimizer: Given a network, the GUI and the Optimizer should be able to communicate effectively and produce the expected file as output.

7. Pass/Fail Criteria

The system will pass if the functionality and performance requirements are met.

6. Suspension Criteria

Suspension Criteria: If any of the tests selected by the member do not give the expected result, then the testing will be suspended until the bug is fixed.

8. Deliverables

- Test Plan.
- Test Case Specification.
- Test input and test output data.

9. Responsibilities

The developer is responsible for all the testing activities.

10. Schedule

Unit Testing – each unit will be tested during implementation.

Integration Testing – as the program units are integrated together, the program will be tested.

11. Approval

Approved by Committee Members.

Reference:
"IEEE Standard for Software Test Documentation", IEEE Std 829-1998

CHAPTER 10: Implementation Plan

The Implementation plan will define the tasks to be completed during implementation. The tasks are as following:

User Manual

The Manual will describe all the features of the software (Pipeline Editor and Optimizer). It will also describe in detail how to use the pipeline editor. The completion criteria for this task would be when all the features and their use have been successfully described.

Architecture Design

The architecture design will be revised every time a change occurs. These changes will be documented along with the component design.

Source Code

The source code will be documented using the javadoc documentation. This source code will comply with the architecture design.

Assessment Evaluation

This assessment evaluation will contain a report of the tests done on the software and the results of these tests in the form of a test log.

Project evaluation:

The project evaluation document will review the process adopted for the implementation of this project and the effectiveness of the methodologies used. The completed software will be reviewed to check if it complies with the initial overview of the project. The product will also be reviewed to check the quality of the product.

The implementation of the software will be considered completed when

- The critical functions of the GUI will be implemented
- The optimizer will successfully compute the optimal distribution
- The GUI will successfully display the result of the simulation

Other documents:

Formal Technical Inspection reports.

CHAPTER 11: Formal Technical Inspection

Introduction

This document provides a formal checklist for the requirement specification document of the software. The purpose of this document is to ensure the quality of the software requirements. The checklist will be evaluated by three students and their report will be documented.

Items to be inspected

The Software Requirements Specification document (version 2.0) will be inspected.

Participants

- Padmaja Havaldar
- Sudershan Kodwani
- Liubo Chen

Criteria

Input: The Inspectors should review the SRS document and evaluate if Yes/No/Partial and suggest comments if needed.

Output: The inspectors' reports.

Formal Technical Inspection Check List

Compatibility

- Do the interface requirements enable compatibility of external interfaces (hardware and software)?

Completeness

- Does SRS include all user requirements (as defined in the concept phase)?
- Do the functional requirements cover all abnormal situations?
- Have the temporal aspects of all functions been considered?
- Does SRS define those requirements for which future changes are anticipated?
- Are all normal environmental variables included?
- Are the environmental conditions specified for all operating modes (e.g., normal, abnormal, disturbed)?

Consistency

- Is there any internal inconsistency between the software requirements?
- Is the SRS free of contradictions?

- Does SRS use standard terminology and definitions throughout?
- Is SRS compatible with the operational environment of the hardware and software?
- Has the impact on the environment on the software been specified?
- Has the impact of software on the system and environment been specified?

Correctness

- Does the SRS conform to SRS standards?
- Are algorithms and regulations supported by scientific or other appropriate literature?
- Does SRS reference desired development standards?
- Does the SRS identify external interfaces in terms of input and output mathematical variables?
- What is the rationale for each requirement? Is it adequate?
- Is there justification for the design/implementation constraints?

Feasibility

- Will the design, operation, and maintenance of software be feasible?
- Are the specified models, numerical techniques, and algorithms appropriate for the problem to be solved?

Modifiability

- Are requirements organized so as to allow for modifications (e.g., with adequate structure and cross referencing)?
- Is each unique requirement defined more than once? Are there any redundant statements?
- Is there a set of rules for maintaining the SRS for the rest of the software lifecycle?

Traceability

- Is there traceability from the next higher level spec (e.g., system concept/requirements and user needs as defined in concept phase, and system design)?
- Does the SRS show explicitly complete coverage of requirements defined by client?
- Is SRS traceable forward through successive development phases (e.g., into the design, code, and test documentation)?

Understandability

- Does every requirement have only one interpretation?
- Are the functional requirements in modular form with each function explicitly identified?

- Is there a glossary of terms?
- Is formal or semiformal language used?
- Is the language ambiguous?
- Does the SRS contain only necessary implementation details and no unnecessary details? Is it over specified?
- Are the requirements clear and specific enough to be the basis for detailed design specs and functional test cases?
- Does the SRS differentiate between program requirements and other information provided?

Maintainability

- Does the documentation follow MSE portfolio standard
- Is the documentation clear and unambiguous

Verifiability/Testability

- Are the requirements verifiable (i.e., can the software be checked to see whether requirements have been fulfilled)?
- Is there a verification procedure defined for each requirement in the SRS?

Clarity

- Are all of the decisions, dependencies, and assumptions for this design documented?
- Are names indicative of their meaning?
- Is each concept defined only once, with one clear meaning?
- Is each statement written as clearly as possible?

Functionality

- Does the design implement the specification and requirements?

Reliability

- Are abnormal conditions considered?
- Are the defect conditions/codes/messages specified completely and meaningfully?

References

IEEE Std 1028-1998, "IEEE Standard for Software Reviews and Audits". 1998 Edition, IEEE, 1983.

"Software Formal Inspections", Software Assurance Technology Center (SATC), 1997, http://satc.gsfc.nasa.gov/fi/fipage.html

Weiss, Alan R. and Kerry Kimbrough, "Fundamentals of Software Inspections, Version 2.1". 1995. http://www2.ics.hawaii.edu/~johnson/FTR/Weiss/weiss-intro

CHAPTER 12: USER MANUAL

I - System Overview

The Pipeline Editor is a feature-rich graphical user interface designed to provide pipeline designers with a graphical view of their pipeline systems and simulation data. This allows for quick pipeline design and data generation. The software integrates an optimizer, which goal is to optimize the time of the simulation. As the simulation is done among several distributed machines, the optimizer will attribute each component of the pipeline system to a particular machine in order to minimize the overall time needed to compute the simulation data. The Pipeline Editor can be started from any computers. Once started, it will connect to the optimizer and the simulator server.

II - System Requirements

- The execution of the software requires Java Web Start 1.2. It is a tool that allows user to access the application from any computer using an Internet browser.
- The user should also have access to the C drive in order to write some data in the temporary folder.
- To start the application, Netscape Navigator or Internet Explorer (or any other browser) is needed. For the first time, an internet connection is needed. After the application has been downloaded, the user will have the choice to integrate the application in the desktop in order to be able to run it offline.

III - Installation and Execution

No particular installation steps are needed. In case the computer does not have Java web Start installed, it will needed to be installed. Visit *http://java.sun.com/products/javawebstart/download.html* to install the latest version of Java Web Start.
To execute the software, go to *http://www.cis.ksu.edu/~oyenan/MyWeb/project/project.htm* and click on *Pipeline Editor* or directly point your browser to this address: *http://www.cis.ksu.edu/~oyenan/MyWeb/project/project.jnlp*. The application should start downloading. A security-warning window will appear. Accept to launch the application. The application will then start.

IV - Getting Started

The application consists of one main window with two toolbars and one menu bar. The vertical toolbar has some buttons representing the pipeline components. The horizontal toolbar contains all the buttons for editing and simulating. The menu bar offers the functionality of the horizontal toolbar in addition to some other functions later described.

4.1 Horizontal Toolbar Description

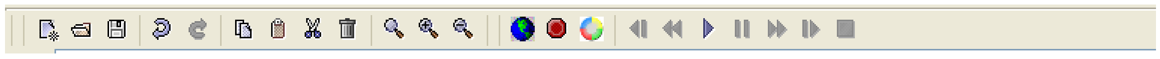


Figure 1: The horizontal toolbar

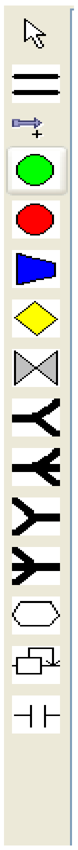
Following is the description of each button of the horizontal toolbar:

- Create a new graph ( )
- Open a graph: ( ) Open a graph file (.vps extension)
- Save the current graph ( )
- Undo : ( )undo the last action
- Redo: ( )Redo the last action
- Copy: ( ) Copy the selected item(s)
- Paste : ( ) Paste a copied or cut item(s)
- Cut : ( )Cut the selected item(s)
- Zoom actual size: ( ) Return the normal scale of the graph
- Zoom in: ( )Zoom in the graph
- Zoom out: ( )Zoom out the graph
- Simulate: ( ) Start the simulation
- Stop : ( ) Stop the simulation
- Optimize: ( ) Start the optimizer
- Replay: ( ) Start the replay session
- Stop : ( ) Stop the replay session

4.2 Vertical toolbar description

<= Figure 2: The component toolbar

The component toolbar is the toolbar with all the components needed to draw the pipeline system. Following is the description of its buttons:



- Selection Tool: ( )
  Used to select any components in the graph. It is always selected by default except when the pipe tool is selected. Use this button to cancel the pipe tool selection.

- Insert Pipe tool:
  Use this tool to insert a pipe between two components. When the tool is selected, the cursor becomes a cross. Rolling over a component port will then cause this port to be highlighted. This indicates the possibility of connecting a pipe to this port. You can then drag the cursor to another port to have a pipe.
  To come back to a mode where components can be moved, you have to select the selection tool.
- Show/Hide Connectors:
  Set the ports of all components in the graph to be visible or hidden. When the ports are visible, a pipe can be directly drawn without selecting the pipe tool. This avoids selecting the pipe tool every time a pipe needs to be drawn. When over a port, the hand cursor will appear, indicating that it is ready to draw a pipe. You can then just drag the hand to another port and a pipe will be drawn.
  If it becomes difficult to grab a component and move it (because the component is too small), you can just hide the ports. This way, you can click anywhere on the component and move it.

- Pipeline Components: You can insert a component by either clicking on the component or dragging its toolbar button into the drawing space. Clicking on the component will drop the component at a default location. Following is a list of all the pipelines component found in the Pipeline Editor:

  Delivery point: Represent a delivery point.

  Receipt point: Represent a receipt point.

  Compressor: Component composed of a compressor and a driver. Type of this component can be set up by right-clicking on the component.

  Joint: Component used to connect two pipes together.

  Valve: Used to connect two pipes. Can have two states: open or close. The state of the valve can be change on the right-click menu.

  Split: Represents a 2-way splitting junction.

  Split: Represents a 3-way splitting junction.

Junction: Represents a 2-way combining junction.

Junction: Represents a 3-way combining junction.

Storage: Component representing a storage.

Regulator: Component representing a regulator.

Orifice: Component representing a orifice meter.

V - FEATURES

5.1 Change component properties

The properties of each component in the graph can be updated by right-clicking on the component and selecting 'Edit Properties'. A property window will open and let you change the values.
For the compressor, it is also possible to change the type of driver and compressor. For that, right click on a compressor and select 'set type'.
The state of a valve (open/close) can also be set. Right-click on the valve and select 'Change State'.

5.2 Name a component

For reference purpose, it is possible to give a name to each component in the graph. Even though this name appears on the property panel, it has no physical meaning and is not mandatory. To change/define the name of a component, double-click on the component. A box will appear and you can type the name inside. You can also right click on the component and select 'rename'.

5.3 Station view ()

a- Create Station

It is possible to create a station with some selected cells. When the cells are selected, right-click anywhere on an empty space of the graph and select 'create station' on the menu. A station will be created. A station can only have one pipe entering and one pipe exiting and should not have any pipe with its source or target out of the station. If this situation happens, a station cannot be created and an error message will occur.

b- Unfold Station

Once a station is created, it is possible to view the component inside it. Right click on the station and selection 'Unfold station'. When a station is unfold, component are visible but cannot be moved individually.

When a station is unfolded, you can access and manipulate components inside the station without having to destroy the station. A first click on the component will select the unfolded station (dashed rectangle enclosing all components) and a second click will select the component inside the station. Once the component is selected, you can manipulate it as it was out of the station. Be aware that if the station is already selected, a click on a component inside will directly select the component.

c- Fold Station

You can fold back the station by doing a right-click on one of the component of the station and select 'fold station' in the menu. If you right-click on an empty space inside an unfold station, you will not be able to have the fold option.

d- Destroy Station

It is possible to destroy the station by doing a right click on the station and selecting 'destroy station'. All the components will therefore be out of the station and will be able to be moved separately.

5.4 Create/Insert Library

Any group of components can be saved as a library and retrieved later. Select all the components to be part of the library. Then go to File->Save As Library. The library will be saved.

To insert a saved library, go to File->Open Library, and then select a valid library name. The library will then be inserted into the current graph. All library names have a .lib extension. Even if the original library name was created without this extension, it will be added automatically. For example, if you save your library as 'myLibrary', when opening it, you need to choose the file 'myLibrary.lib'.

5.5 Save/Open

At any time, the graph can be saved. Just click on the save icon or go to File-> Save and choose a name.

To open a graph, click on the open icon or go to File ->Open and choose the name of the graph to open. Make sure to have saved all previous work before opening a new graph. All graph files should have a .vps extension. Even if the original library name was created without this extension, it will be added automatically. For example, if you save your graph as 'myGraph', when opening it, you need to choose the file 'myGraph.vps'.

5.6 Cut/paste/copy

To cut or copy, select the component(s). To select a component, just click on the component. To select a group of components, drag the mouse to draw a selection square enclosing all the desired components. Selected components will be highlighted in green. Once the components are selected, click on the cut or copy icon. If there are some items previously cut or copy, you can paste them and they will appear on the graph.

5.7 Remove

To remove a component, select the component and click remove. If a group of components is selected, all the components will be removed. When a component is removed, all the pipes connected to it are also removed. Notice that data cells cannot be removed. They are always associated with a component. They can just be hidden.

5.8 Zoom

By clicking on the zoom icons, it is possible to do a zoom in, zoom out or to come back to the actual size of the graph.

5.9 Optimize

When the graph is completed and is ready for simulation, you need to first run the optimizer by clicking on the optimizer icon or by going to Tool->Optimize.
An error message will appear if the current graph has not been saved.
The parameters of the optimizer can be defined by going to Tool->Set optimizer parameters. There, you can specify the time to wait before interrupting the optimization. Usually, for a medium network, a time of 5 minutes will give some satisfying results.
When the optimizer is running, you can query its state to determine whether or not it is done. For that, go to Tool –>Check Optimizer State.
When the optimizer is done, it is advised to save the graph again. By doing that, the new information creates by the optimizer will be saved and you will not have to optimize the graph next time you open the file.
Be aware that components inside stations will be optimized separately, just as any other components.

5.10 Simulate

Once the optimizer is done, the simulation can be executed. Click on the simulation icon or go to Tool -> Start Simulation. When opening a file that has already been optimize, it is not necessary to optimize the graph again. The simulator will run and after some time, you will see the first results coming.

At any time, the simulation can be stopped by clicking on the stop button. Once the simulation is stopped, it can only restart from the beginning. To review data previously simulated, you can use the replay option.

5.11 View simulation data

For each component expect pipes, it is possible to have a summary view of the data from the simulation. Right click on the component and select ’show data’. The data show the pressure, temperature and mass flow of the component.
When a data cell is visible, you can hide it by right clicking on the component associated to it and select ‘Hide data’. Summary data are always linked to a component. Therefore, it is easy to know which component they refer.
For all components, it is also possible to display all the data. For a pipe, right-click on it and select ‘display data’. For any other components, right-click on the data cell (it has to be visible) and select ‘display data’. A window will appear with all the simulation data. Notice that simulation data cannot be modified.

5.12 Replay

After each simulation, it is possible to review all the data generated during the simulation. Click on the play icon in the toolbar and the replay function will be started. If there are no simulation data available, an error message will appear.
At any time, the replay can be stopped by clicking on the stop button.

5.13 Bend pipes

With Shift-click on a pipe (maintain shit and click on the pipe), it is possible to add a bending point to the pipe. This function is just provided for a better display and has no real physical meaning. Once a bending point is created, you can bend the pipe by dragging the bending point. To remove the bending point, do a Shift-click on the point.

VI – FAQ

Q: When I click on the link, the application does not start.
A: If the browser asks you to open the file, which means you do not have Java Web Start installed on your computer. Go to http://java.sun.com/products/javawebstart/download.html and install the latest version of Java Web Start.
If you have Java Web Start, verify that you have permission to write on the C: drive of your machine.

Q: The program crashes when I run the optimizer or the simulator.
A: The server is not running. Contact the administrator.

Q: When I want to move a component, it starts drawing a pipe.
A: Either the Pipe tool is selected (cross cursor) or you are over a port. For small components, an easy way to move them is to hide the ports. This way, you will never be over a port.

Q: I do not see any data coming when I run the simulator.
A: You did not save the graph after having run the optimizer. When optimizing, a mapping is done between cells from the graph and components from the simulator. If the graph is not saved, the mapping is lost and the simulator cannot map the data with the cells in the graph. The solution is to restart the optimization.

CHAPTER 13: Technical Manual

I- Purpose

The goal of this document is to provide a general description of how to modify or update certain functions of the pipeline editor. It also provides a description of the function of some elements. For more information about the classes and methods, refer to the Design document and the API document available online.

II - Description

Following is a general description for:

- Adding and modifying components.
- Mouse click handling and popup menu
- Mapping cell-jobComponent

2.1 Adding and modifying components

The main class to insert and modify components is the class MyGraph. This class defines all the properties for the components (by creating UserObject objects). Each component (compressor, joint, valve…) has a userObject that hold its properties. For this reason, the display of the properties dialog box is done by the class MyUserObject.
Here are all the steps to add a new component:

1- Define a new cell class for the component (similar to CompressorCell class).
2- Define a view for the component (similar to CompressorView class). In the view, the paint method for the new component has to be specified.
3- In the MyGraph class, associate the cell with the view (method createVertexView()).
4- Define the properties of the new component by adding a method in MyGraph that return an UserObject holding the properties of the component.
5- Define a property dialog for the component in the class MyUserObject (optional).
6- In MyGraph class, add the component cell in the insert() method to allow the new cell to be inserted in the graph.
7- In the Editor class, add a new button to the toolbar corresponding to this new component.
8- Create a new class extending JobComponent to have a job component associated to this new component. The new job component should use the

cell's userObject in order to initialize its fields (see Compressor.java). The execution time of the new job component is also defined in this class.

9- In Mediator.createJob(), associate the new component cell to the new job component created. This method also defines the local and remote communication time for all the components.

Example: Let's add a new compressor that face the opposite direction of the current one (like this). We are going to call this component compressor2.

1- Define Class Compressor2Cell:

```
public class Compressor2Cell extends MyCell  {
   public CombineCell(Object userObject) {
     super(userObject);
   }
 }
```

2- Define Class Compressor2View

```
public class Compressor2View extends VertexView {
   static Compressor2Renderer renderer = new Compressor2Renderer();

public Compressor2View(Object cell, JGraph graph, CellMapper cm) {
                    super(cell, graph, cm);
   }
   public CellViewRenderer getRenderer() {
     return renderer;
   }

   public static class Compressor2Renderer extends VertexRenderer {
          public void paint(Graphics g) {
                    int b = borderWidth;
                    Graphics2D g2 = (Graphics2D) g;
                    Dimension d = getSize();
                    boolean tmp = selected;
                    int[] xPoints = {b-1,b-1,d.width-b,d.width-b};
                    int[] yPoints = { d.height*3/8,d.height*1/8, b-1,d.height/2 };
                    int[] xPoints2 = {b-1,b-1,d.width-b,d.width-b};
                    int[] yPoints2 = {d.height*9/16,d.height,d.height,d.height*9/16};
                    if (super.isOpaque()) {
                              g.setColor(super.getBackground());
                              g.fillPolygon(xPoints, yPoints, xPoints.length);
                              g.fillPolygon(xPoints2, yPoints2, xPoints2.length);
                              g.drawLine(d.width/2,d.height*7/16,d.width/2, d.height*9/16 );
```

```
        }
        try {
                setBorder(null);
                setOpaque(false);
                selected = false;
                super.paint(g);
        } finally {
                selected = tmp;
        }
        if (bordercolor != null) {
                g.setColor(bordercolor);
                g2.setStroke(new BasicStroke(b));
                g.drawPolygon(xPoints, yPoints, xPoints.length);
                g.drawPolygon(xPoints2, yPoints2, xPoints2.length);
                g.drawLine(d.width/2,d.height*7/16,d.width/2, d.height*9/16 );

        }
        if (selected) {
                g2.setStroke(GraphConstants.SELECTION_STROKE);
                g.setColor(graph.getHighlightColor());
                g.drawPolygon(xPoints, yPoints, xPoints.length);
                g.drawPolygon(xPoints2, yPoints2, xPoints2.length);
                g.drawLine(d.width/2,d.height*7/16,d.width/2, d.height*9/16 );
        }}}}
```

Notes:

- The class Compressor2View also defines the renderer for this class. This could have been done in a separate class called Compressor2Renderer.
- The paint method defines 3 types of view: opaque, non-opaque and selected. When the component is opaque, it is filled with the proper color. When it is not opaque, only the perimeter is drawn (with the borderColor). We also need to define how the component is viewed when it is selected. In this case, using the predefined selection stroke (green dash line), we are just drawing the perimeter. We could have drawn the enclosing rectangle instead.
- Each component has a size (rectangle) defined when it is created. It will be painted inside this rectangle (its dimension are d.width and d.height).

3- <u>Associate the cell with the view</u>: Class MyGraph.createView()

```
protected VertexView createVertexView(Object v, CellMapper cm) {
                if (v instanceof JointCell)
                        return new JointView(v, this, cm);
                else if (v instanceof CompressorCell)
                        return new CompressorView(v, this, cm);
                else if …
                …
```

```
                        else if (v instanceof Compressor2Cell)
                                return new Compressor2View(v, this, cm);
                        return super.createVertexView(v, cm);
        }
```

4- Define the properties: MyGraph.createUserObject(). Let's say that Compressor2 has 3 properties: Temperature, Pressure and Mass with a default value of respectively 10.1, 20.2, 30.3

```
        private MyUserObject compressor2UserObject(){
         String s;
          MyUserObject userObject = new MyUserObject("compressor2");
          s =new String("10.1");
         userObject.putProperty("Pressure", s);
          s =new String("20.2");
          userObject.putProperty("Temperature", s);
          s =new String("30.3");
          userObject.putProperty("Mass", s);
  return userObject;

}
```

Notes:

- The properties and the values are of type String. Therefore, when reading the value, it has to be cast in the proper type (generally double or int).

5- Define the property dialog

A default propertyDialog (displaying the properties) and dataDialog (displaying the data) will be created. A default property dialog is created for each userObject. There is no need to create one unless the dialogs have to display different information than the properties stored in the userObject. To create a custom property dialog, go to MyUserObject class and define the new dialog box.

```
protected void showCompressor2Property(final MyGraph graph, final Object cell) {
        // create JDialog compressor2Dialog
        //populate the dialog box
        // compressorDialog.show()
}
```

Add a call to this dialog box in MyMarqueeHandler.createPopupMenu().

```
public JPopupMenu createPopupMenu(final Point pt, final Object cell) {
        JPopupMenu menu = new JPopupMenu();
        …
        if (cell instanceof Compressor2Cell) {
                menu.add(new AbstractAction("Edit Compressor2") {
                                public void actionPerformed(ActionEvent e) {
```

```
        ((MyUserObject)(((DefaultGraphCell)cell).getUserObject())).showCompressor2P
roperty(graph,cell);                                             }
                });
        …
```

Note:

- If a special dialog is created, the default one has to be canceled.

6- Insert the component: MyGraph.insert(). Let's create the part of code to insert a component of type COMPRESSOR2 (this type will be define in the next step).

```
public void insert(String type, Point point) {
Hashtable attributes = new Hashtable();
        int u = GraphConstants.PERCENT;
                Map mapPort;
   // Construct Vertex with no Label
   DefaultGraphCell vertex = new DefaultGraphCell();
   DataCell data = new DataCell();
…

// *************Insert a compressor2*****************
  if (type.equals("COMPRESSOR2")){
          MyUserObject userObject = compressor2UserObject();
         vertex = new Compresso2rCell(userObject);
         data.setUserObject(userObject);
        // Default Size for the new Vertex
        size = new Dimension(50,75);

        // Add a Port
                mapPort = GraphConstants.createMap();
                GraphConstants.setOffset(mapPort,new Point(0, (int) (u / 4)));
                DefaultPort port = new DefaultPort("left");
                vertex.add(port);
                attributes.put(port,mapPort);

                mapPort = GraphConstants.createMap();
                GraphConstants.setOffset(mapPort,new Point(u, (int) (u / 4)));
                port = new DefaultPort("right");
                vertex.add(port);
        attributes.put(port,mapPort);

        ((CompressorCell)vertex).setDataCell(data);

        }
```

Notes:

- A vertex is created with a compressor2UserObject. Recall that this userObject holds all the properties for the component. This vertex has a data Object (to display summary data) and a size (size of the enclosing rectangle; used in step 2).
- Depending on the component, we have to define a certain number of ports and their position. The position is relative to *u*. This variable can be seen as the width or length of the enclosing if used respectively in the x-coordinate or the y-coordinate. In our case, the port will be at 1/4th from the top of the enclosing rectangle.
- Each port has a fixed name as defined in the naming conventions (Section 3).

7- <u>Add a new toolbar button</u>

```
public JToolBar createToolBar2() {
   JToolBar toolbar = new JToolBar(SwingConstants.VERTICAL);
   toolbar.setFloatable(false);
// InsertCompressor2
   URL comp2Url = getClass().getClassLoader().getResource("gif/comp2.gif");
   ImageIcon comp2Icon = new ImageIcon(comp2Url);
   compressor = toolbar.add(new AbstractAction("Comp", comp2Icon) {
     public void actionPerformed(ActionEvent e) {
                  graph.insert("COMPRESSOR2",new Point(10, 20));
     }
   });
      compressor2.setToolTipText("Compressor2");
…
MouseMotionListener ml = new MouseMotionAdapter() {
         public void mouseDragged(MouseEvent e) {
            JComponent c = (JComponent)e.getSource();
            TransferHandler th = c.getTransferHandler();
            th.exportAsDrag(c, e, TransferHandler.COPY);
         }
      };
      compressor2.setTransferHandler(new
ButtonTransferHandler("COMPRESSOR2"));
      compressor2.addMouseMotionListener(ml);
…
```

Notes:

- You should have an image icon for the new component (in this example comp2.gif). Images are 24 x 24.
- The action when the button is pressed is to insert compressor2 into the graph. The type specified when calling graph.insert() should match the type used in MyGraph class (step 6).
- The MouseMotionListener is used to handle Drag & Drop. Each button in the toolbar has to be notified when a drag gesture is started.

8- Create a JobComponent for the new component. Recall that compressor2 has 3 properties: pressure, temperature, mass.

```
public class Compressor2 extends JobComponent implements Serializable{
private double pressure, temperature, mass;
public Compressor2(MyUserObject userObject){
		super(1);
		componentId = c++;
		gasType = new
Integer((String)(userObject.getProperty("gasType"))).intValue();
		number = new
Integer((String)(userObject.getProperty("number"))).intValue();
		String indexVal = (String)(userObject.getProperty("index"));
		String valueVal = (String)(userObject.getProperty("value"));
```

Notes:

- The execution time is defined in the constructor. It is the parameter of the superclass constructor. In this case, the execution time is 1.
- The initialization of the fields comes from the userObject. As the property values are Strings, a casting in the proper type is necessary.
- Get and set methods have to be defined for each field.

9- Associate the component cell to the job component: class Mediator

```
private Vector createJobs(){
hash = new Hashtable();
for (Iterator iter = cells.iterator(); iter.hasNext();){
	JobComponent j = null;
	DefaultGraphCell o = (DefaultGraphCell)(iter.next());
	if (o instanceof CompressorCell)
		j = createComp2Node(o);
	else if (o instanceof Compressor2Cell)   // o is a compressor2
		j = createComp2Node(o);
	else if…
	…
	if (j != null){
		hash.put(o,j);
}

private JobComponent createComp2Node(DefaultGraphCell cell){
	MyUserObject userObject = (MyUserObject)(cell.getUserObject());
	return new Compressor2(userObject);
}
```

Note:

- The jobComponent is created from the userObject of the cell stored in the hashtable for future reference.

2.2 Mouse click handling and popup menu

All the mouse events are handled in the class MyMarqueeHandler. The popup menus are also created in this class. Every time a click occurs, this class detects the cell on which the click has occurred and initiates the proper action (see example step 5).
This class also handles the pipes creation. The userObject for the pipes are defined in the class MyMarqueeHandler (as opposed to MyGraph for all other components).
The decision of whether or not some components should accept pipes sources or targets is taken in the class MyModel.

Example : Accept source only from the left of compressor2.

```
public class MyModel extends DefaultGraphModel {
public boolean acceptsSource(Object edge, Object port) {
        if ((((DefaultPort)port).getParent() instanceof Compressor2Cell)){
                if (((DefaultPort)port).getUserObject().toString().equals("right"))
                        return false;
                else return true;
        }
        …
…
}
```

2.3 Mapping cells and jobComponents

In order to optimize or simulate the graph, a mapping has to be done between cells from the graph and Job Component used by the optimizer and the simulator. This mapping is done by the Mediator class. This class holds 2 static hashtables: one for the mapping cell–JobComponent and another one for the mapping JobComponent-Cell. This class is the link between the graph and the optimizer and the simulator. This is in the mediator class that data of the simulation are updated inside each cell.

III- Naming Conventions

There is some naming conventions for the files and variable names used by the application.

3.1 File names

The graph files are saved with the extension '*.vps'*. Those files are saved on the client machine and just contain information for rebuilding the graph. An vps file is the serialization of the view and the model of the graph. An example of file would be '*test.vps*'.
The optimizer files use the extension '*.opt*'. They use the basename of the graph file saved by the user. For instance, if a user save a graph under 'test.vps', the optimizer file will be named 'test.opt'. For this reason, the user is prompted to save the graph before optimizing. Optimizer files are saved on the server side. They are used by the simulator. An opt file is a serialized vector containing all the JobComponents created from the graph cells. Those JobComponents contain information generated from the optimizer about the machine on which they should be executed.
The simulator files use the extension '*.sim*'. The file name is created by adding the timestamp of the simulation to the basename of the graph file saved by the user. For instance, the 5th set of data produced by the simulator will be saved under '*test5.sim*'. The initial file is named '*test0.sim*'. It is the same data as the original file received from the optimizer. Simulator files are the serialization of a vector containing the JobComponents. Each JobComponent in this file has been updated with new values coming from the simulation.

3.2 Variable names

The only variable names that are fixed are the name of the ports and the name of the data edges (edges linking a cell with its data). For components having 2 ports, the left port will be called '*left*' and the right port '*right*'.
<u>Example</u>:
DefaultPort port = new DefaultPort("left");

For components with more than one left port, the names of the left ports should contain the string 'left' (no matter what the name is, i.e topLeft). Same for components with more than one right port. This naming convention helps to easily identify the ports.
The data edge name is '*data*'. Knowing this name helps making the distinction between a data edge and a pipe (which is also an edge).
<u>Example</u>:
DefaultEdge edge = new DefaultEdge("data");

IV- Communications

The GUI, on the client side, has to communicate with the optimizer and the simulator on the server side.

4.1 GUI-Optimizer

The protocol of this communication is very simple. The GUI communicates via the OptimizerClient class. First, the OptimizerClient opens a connection to the server on port 3333. Then it sends a list of jobs (a vector). After, it sends a mapping (id,JobComponent), then the file name and finally a time. The time is the optimizer time, input from the user. The default time is 2 minutes. The file name is the name under which the graph has been saved. It is needed to save the optimizer file under the same name. The mapping (id, JobComponent) is needed by the Branch and Bound algorithm in order to find the JobComponent from any given job id. The list of jobs is a vector of all jobs components created from the cell of the graph. The vector is created by the method Mediator.createJobs().
On the other side, the optimizer (the server), receives those objects and starts the computation. Whenever an error occurs, it sends a message (REJECT) to the OptimizerClient that notifies the GUI. If all the information has been received properly, it sends an ACCEPT message. When it is done, it creates a file that will be used by the simulator and send a DONE message.

4.2 GUI-Simulator

The protocol of this communication has been specified in the Formal Specification document. The communication is done via the SimulatorClient that connects to the simulator server on port 4000. The optimizerClient receives commands from the GUI and passes them to the simulator that executes the proper action. The commands are: Stop, sendFile, Replay.
To start the simulation, the GUI initiates a sendFile command. The OptimizerClient then transfers the optimizer filename (test.opt) to the simulator.
For a replay, it sends the filename of the simulator initialization file (test0.sim).
In both cases, the simulator reply by an ACCEPT if the file exists or REJECT if not. If the file is accepted, the simulator start sending data either by computing them for a simulation command or by taking them from the file previously stored in the case of a replay command. The OptimizerClient receives the data and notifies the Mediator that updates the display. As each JobComponent is mapped to a graph cell, the data are fetched from the JobComponent and updated in the corresponding cell's userObject. For a simulation, each time a new set of data is transferred to the client, a new file is created. Those files are used for the replay and follow the naming convention defined earlier.
At any time, the user can stop the simulation or the replay. A stop message is then sent to the simulator, which, upon reception of this message, stops sending data and returns to an idle state.

V- Java Web Start

Java Web Start is used to access the application from any browsers. When using Web Start, the application can be untrusted and run in a sandbox. However, due to the

sockets access to the optimizer and the simulator, the code has to be signed in order to use the client network. To be able to start, the application must come in a jar file and with and jnlp file. The jnlp defines the name, path, description, and main class of the application. It also defines the type of permission is required. For the meaning of all the tags and their possible values, refer to the developer guide of Web Start at: http://java.sun.com/products/javawebstart/1.2/docs/developersguide.html#filecontents.
Following is the jnlp file used for the application:

```
<jnlp spec="0.2 1.0"
    codebase="http://www.cis.ksu.edu/~oyenan/MyWeb/Project/"
    href="project.jnlp">
  <information>
    <title>Pipeline Editor</title>
    <vendor>KSU CIS</vendor>
    <homepage href="http://java.sun.com/products/javawebstart/demos.html"/>
    <description>A Pipeline editor test</description>
    <description kind="short">Pipeline editor Description</description>
    <icon href="gif/pipeline.gif"/>
    <offline-allowed/>
  </information>
  <security>
   <all-permissions/>
  </security>
  <resources>
    <j2se version="1.4+" href="http://java.sun.com/products/autodl/j2se"/>
    <j2se version="1.4+"/>
    <jar href="project.jar" main="true" download="eager"/>
  </resources>
  <application-desc main-class="Editor"/>
</jnlp>
```

Following are the step to provide a signed jar file.

- *jar cmf MyManifest project.jar *.class gif optimizer org*

This will put all the class file in the jar. It will also put the following directories:

  - \gif: directory containing all the icons
  - \optimizer: classes for the optimizer package
  - \org: JGraph classes

The file MyManifest simply specify which of those classes contain the main method.

- *keytool –genkey –keystore myKeys –alias jdc*

This generate a key stored in the file *myKeys.* A password will be asked to generate the key. This file is available and the password is '*pipeline*'. If using the file *myKeys,* this step is not necessary (as the key has already been generated).

- *jarsigner –keystore myKeys project.jar jdc*

This will sign the jar file with the key contained in the file *myKeys*. The password used when creating the file will be asked. If using the provided file, it is going to be "pipeline".

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